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"We most strongly recommend the work to all our readers who have a taste for plants, and more especially to all young gardeners."—*Gardener's Magazine, April* 1839.

VEGETABLE ORGANOGRAPHY;

OR,

AN ANALYTICAL DESCRIPTION

OF

THE ORGANS OF PLANTS.

BY

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VEGETABLE ORGANOGRAPHY.

BOOK III.

OF THE REPRODUCTIVE ORGANS, OR THE PARTS ESSENTIAL TO REPRODUCTION.

INTRODUCTION.

As soon as an organized being, and particularly a plant, or a part of one, commences its visible existence, it only presents to us a development of organs; whence it has been concluded sometimes as a reality, at others as a figurative expression, that all these beings proceed from a germ. This name of Germ has been given to a body imperceptible to our senses, which is supposed to exist in organized bodies, and to be or to contain in miniature the body, or the part of one, which proceeds from it. The germs may be considered either as being formed by the organ, or by the being upon which they are developed, or by that which is transmitted to it at the period of fecundation; and in this case, the force which causes this creation of germs, is termed the Plastic Force: or, it is supposed that the origin of these germs dates from the origin itself of organized beings, that they were all inserted into one another; so that all the germs

of a given species, which are and will be developed, were all contained in one another, and all in the first which existed.

These two contradictory theories are so vast, that they seem to contain all the opinions of which the subject is susceptible, and, consequently, one of the two must be true. However, if we reflect, one is almost as unintelligible as the other; for — 1st, on the one hand, nothing among known facts can make us comprehend the creation of a germ, since we never see anything more in the Inorganic Kingdom than transformation of compositions; and, in the Organic, than developments; and, 2d—Nothing can make us conceive, either in imagination, or in reason, an indefinite insertion of pre-existing beings.

If we separate these questions, which are more metaphysical than physical, and limit ourselves to general facts, we shall see that an insertion, (if this idea be not extended too far,) is proved by evident examples, as in *Volvox*. We shall perceive, 2d, that the germs, or rudimentary beings, are often visible a long time before their ordinary appearance; as, for example, when we find in the centre of the trunks of palms the floral scapes which would be developed externally after several years. 3d. We shall be obliged to acknowledge that all beings are developed, as if their nutritive matter, deposited in an invisible and pre-existing receptacle, had its place, thus to speak, fixed before hand.

Thus, whether the expression of Germ be taken either as a reality, or as an image, it will serve equally well to describe the origin of organized beings. In the two hypotheses, these germs arise from certain organs; in the theory of Plastic Forces they are formed by them, in that of the pre-existence of germs they are simply nourished and developed by their action. Whichever it be, they are presented in plants in two different states; either they are disposed in such a manner as to be

developed as a natural effect of the laws of nutrition, as takes place in the development of branches, tubercules, offsets, layers, and suckers, for all these bodies may be considered as resulting from the development of germs more or less latent; or their development requires a preliminary operation, which has been named fecundation, which tends to give the germ a proper life, and this is performed by means of a complicated apparatus of organs, which collectively constitute the flower. Reproduction without fecundation, not presenting any organic apparatus which is peculiar to it, will not occupy us in detail before we treat of the functions of plants; whilst reproduction by fecundation, or sexual reproduction, being caused by numerous and various organs, will henceforth engage all our attention. It has a double claim in this respect, for it is important that all the floral organs should be well understood, not only because they perform one of the principal functions of vegetation, but also because it is upon their constant forms within certain limits, varied *ad infinitum* in the different species, and remarkable for their symmetry, it is, I say, upon these forms, that all the classification of plants rests.

With regard to the general appearance of the organs of fructification, plants are distinguished into PHANEROGAMOUS and CRYPTOGAMOUS: the former are those which have their flowers visible to the naked eye, more or less symmetrical, and with distinct sexual organs; the latter are those which have the flowers (if indeed they have any) visible only to the microscope, scarcely, if at all symmetrical, and the sexual organs not distinct. The former comprehend all Exogens, and the greatest part of Endogens; the latter all Cellulares, and some Endogens. We proceed now to study the organs of Reproduction, following this fundamental division of Phanerogamous and Cryptogamous plants.

CHAPTER I.

OF THE INFLORESCENCE, OR THE DISPOSITION OF THE FLOWERS OF PHANEROGAMOUS PLANTS.

I DESIGNATE, with botanists, under the name of the INFLORESCENCE, the collective distribution of the flowers of a plant; or, as Rœper calls it, that part of the stems or branches which bears no other branches but the floral axes. This term must be distinguished from that of the FLOWERING, which means only the expanding of the flowers; the study of the inflorescence forms an essential part of Organography, that of flowering is essentially physiological.

The organs of the inflorescence are the supports of the flowers comprised under the name of PEDUNCLES, or PEDICELS, and the accessory envelopes of the flowers, or the BRACTS. We shall commence by first examining the general disposition of the flowers, and afterwards study separately their supports and envelopes. Throughout the whole of this chapter, we shall be principally guided by the excellent Mémoire of Turpin; by the ingenious ideas which Mr. Robert Brown has occasionally advanced upon this subject in different places in his works, particularly in his remarks upon the Compositæ; and by a very remarkable Mémoire, which M. Rœper has been so kind as to communicate to me; and lastly, by several observations of my own.

Section I.

Of the Inflorescence in general.

A flower, considered in an organographical point of view, is an assemblage of several verticils (usually four) of foliaceous origin, disposed above or within one another, and so close that their internodes are not distinct.

These verticillate organs being, then, lateral, it would seem that the stem or branch which bears the flower would be prolonged beyond it; and this prolongation does, in fact, take place sometimes accidentally: Turpin has figured some examples, and I have myself observed it in the Pear and Rose. Of the latter I have given a figure here (Pl. 17); but it is not usually so, and it almost always happens in the natural course of things that the flower truly terminates the branch, which is so exhausted by the abundant nourishment which the different floral organs attract, that it has not the vegetative force necessary for its prolongation; this only takes place, in the cases above mentioned, when the flower, being sterile, attracts the juices but little, and the branch at the same time is well nourished. It may, then, be declared as a general law, that the flower is terminal with respect to the branch which bears it.

This branch has received the name of Pedicel *(Pedicellus)*. It is sometimes long and distinct, at others very short and hardly visible; in this case it is usual to say that the flower is Sessile, which only signifies in Organography that its pedicel is very short.

Since, then, every flower is terminal upon the pedicel, the whole study of Inflorescences ought to rest upon

the different positions of the pedicels, with regard to the organs which bear them. They may arise either immediately upon the stem or principal branch, or spring from parts of the stem or branches which are more or less different from ordinary ones; in this case these floral stems or branches bear the collective name of PEDUNCLES *(pedunculi)*.

The pedicels may arise upon the stem or branches after two systems—either laterally to the axil, or at the extremity of the branch which bears them. We are about to follow the numerous and varied consequences of these two modes of inflorescence; but, before entering into any detail, it is necessary to say that the name of FLORAL LEAVES is given to those, from the axil of which a pedicel proceeds, provided that they do not differ from ordinary ones; and that they are called BRACTS, when they differ in size, colour, form, or texture. Bracts differ especially from ordinary leaves, in never having true buds in their axils; and in this respect they nearly approach the verticillate organs, which compose the flower.

We shall study the different inflorescences in the following sections: — 1st. Axillary Inflorescences. 2d. Those which are terminal. 3d. Those which partake of both these modes. 4th. Those which form, or seem to form, an exception to the preceding classes.

Section II.

Of Axillary, or Indefinite Inflorescences, or those with a Centripetal Evolution.

The branches bear the flowers laterally, and in a scarcely definite number. They may be terminated by a flower bud, which we shall examine in the following section: or by a bud, in this case, which forms the subject of this section, sometimes the branch does not flower; sometimes it bears flowers in the axils of the leaves, and the branch itself may elongate by the development of the terminal bud. Let us follow the details of this axillary position of the flowers, and let us first take the most simple cases.

If we examine the vegetation either of the Periwinkle *(Vinca Major)*, or *Veronica hederacea*, &c., we find that their stems or principal branches give rise to a flower from most of their axils, and that the stem or branch is prolonged by the apex; and as the leaves of the axil, from which the pedicels arise, are not perceptibly different from ordinary ones, and as the length of their internodes is well marked, we are content, in describing the inflorescence of these plants, and all which resemble them in this respect, to say, that their pedicels are axillary and solitary. When the development of the leaves, and all the organs of those plants, proceeds from the base of the stem towards the apex, we remark that their lower flowers are developed first, and the expansion of them continues from the base upwards. Now, from this which is observed so clearly in plants with axillary pedicels, we shall proceed to discover it with more or less decided variations in all those which have not a terminal inflorescence.

It usually happens, especially in erect stems, that the upper leaves, even when they do not bear flowers, are smaller, and have their internodes shorter than the lower ones, which results from their slower development, and their receiving less nourishment. This double effect is greatly augmented if these same upper leaves bear a flower in their axil, probably because this flower attracts a part of the nourishment, which would otherwise have been employed either in making the leaf larger, or elongating the internode; in this case the leaf is called the floral one, or bract, and the top of the stem or branch, thus organized, receives the name of the TERMINAL RACEME, or SPIKE. It seems, in fact, to terminate the stem, but it is only formed of axillary flowers, and the stem only ceases to elongate by the exhaustion which it suffers in developing the flowers and nourishing the seeds; it then terminates in a point by the simultaneous abortion of the flowers and bracts. It is well known that by much nourishment these branches can be made to elongate beyond their ordinary dimensions; sometimes they are naturally prolonged in an unusual manner. Thus in the Pine-apple and *Eucomis*, the axis of the stem is prolonged at the apex, and it ceases to bear flowers; then the leaves which were small and membranous where they had axillary flowers, become large and truly foliaceous here where they have none: it is this which forms the crown which surmounts the spike of the Pine-apple and the raceme of *Eucomis*. An analogous phenomenon is met with in *Callistemon*, and some other Myrtaceæ of New Holland; the axis of the spike is prolonged at the apex, and forms, above the inflorescence, a true branch with leaves: this phenomenon also accidentally happens in some cones, the axis of which is prolonged into a leafy branch (Pl. 16, fig. 4). It is to the inflorescence similar

to what takes place in the flower when its axis is prolonged, as we have seen above.

We may connect with these facts that which happens in *Hoya carnosa*, although it relates to the prolongation of the peduncle, and not to that of the stem. The peduncle, or floral branch, arises from the axil of the leaves; the first year it bears a kind of umbel composed of pedicels, which are developed in the axils of very small bracts. These pedicels disarticulate and fall off after flowering, but the peduncle remains several years: at each period of flowering it is prolonged a little at its extremity, and it bears the traces of all the successive flowerings, as if they were the remains of a raceme of the same year. The fact is remarkable, as presenting the only example that I know of a peduncle which persists and flowers several years in succession.

There is so little difference between flowers said to be arranged in racemes, or spikes, and those said to have axillary pedicels, that it is not rare to find stems or branches in which both states are united; thus in several species of *Digitalis*, and a multitude of other plants, the lower flowers are solitary in the axils of large and distant leaves, whilst the upper ones are in the axils of bracts, which are small and near together. Descriptive botanists have been accustomed to designate this intermediate state by the terms of a RACEME, or SPIKE, INTERRUPTED AT THE BASE, or WITH LEAVES AT THE BASE. In a number of cases we see the lower flowers solitary in the axils of leaves, which gradually diminish, approach each other, and the flowers then form a true raceme. All the difference between this case and that of ordinary racemes is, that sometimes the transformation of the floral leaves into bracts takes place suddenly from the first, which bears a flower in its axil; sometimes only gradually as they approach the top.

If now, instead of studying the formation of the raceme in a single stem, we examine what happens in the branches of a branching one, we shall find evidently that each of them may present the same phenomenon, and as the branches spring from the axils of leaves, axillary racemes will thus be formed. These kinds of racemes then are only floral branches: sometimes they bear also at their base a certain number of leaves, which, having no flowers in their axils, retain their natural forms, and then they are considered as so many distinct racemes, or we are contented to say, that the plant bears several; sometimes towards the base they have their leaves provided with flowers and changed into bracts, so that the axillary raceme is without leaves, properly so called, then the whole is considered as a single inflorescence, and the name of COMPOUND RACEME is given to it. Thus all racemes which spring from the axils of leaves only differ from terminal ones in their being placed at the top of a branch instead of a stem. Their flowers arise from the axils of bracts, or floral leaves, and the whole branch from the axil of a leaf.

All that we have said in taking the raceme for an example is applicable, with very slight differences, to the different kinds of indefinite inflorescence which we are now about to pass rapidly in review, viz.—the Spike, the Raceme, the Umbel, and the Capitulum, with the varieties of each.

1st. The name of SPIKE *(spica)* is given to those indefinite inflorescences where the flowers arise from the axils of leaves, either sessile, or borne upon a scarcely visible pedicel, as, for example, in the Plantain. The limit between the spike and raceme is very uncertain, seeing that it only rests upon an appearance; in fact, the pedicel always exists, and its length alone is

variable: thus it is not rare to find inflorescences which are racemes at the base, and spikes above, or which are spikes in their infancy, and become racemes when they are older. When several floral branches have flowers in a spike, and are so close together as to seem to form a single inflorescence, the name of BRANCHING SPIKE is given to it; as, for example, in *Statice spicata*, a variety of *Plantago lanceolata*, &c.

We describe, under the particular name of CATKIN *(amentum)*, certain spikes which are remakable for this—that after the flowering of the male flowers, or the fructification of the female, has been performed, the axis of the spike dries up, and disarticulates at the base; such are the male inflorescences of the Hazel, Oak, &c., and those of the two sexes of the Willow. The difference between the catkin and spike is less distinct in reality than it appears to be; and it frequently happens, for example, that in the same species of Willow the male flowers are in a catkin, or caducous spike, and the females in a permanent one. There are some spikes, the flowers of which are slightly pedicellate, and approach the raceme. In Firs we find branching catkins, formed of a central branch and several lateral ones.

The name of CONE *(conus strobilus)* is given to the female spikes of the Coniferæ, which are furnished with very large bracts. The female spikes of the Hop are kinds of cones with membranous bracts.

The flowers of almost all the Gramineæ are alternate, and closely arranged along an axis, at the base of which are found one, or, more frequently, two peculiar bracts, which are called glumes. We give this inflorescence the name of SPIKELET *(spicula, locusta)*; and as these spikelets are found in almost all the Gramineæ, it is usual to say that their flowers are spiked when the

spikelets are arranged in spikes, as in the Wheat, and that they are paniculate when they are in a panicle, as in the Millet and *Agrostis*.

The Spadix is also a kind of spike to which a particular name is given; it is applied to the spike of Monocotyledons, when they are enveloped in their young state by a large sheathing bract, which completely surrounds them, and is called the Spathe. The spadix is simple, in *Arum*, for example, and sometimes it is covered with flowers throughout its whole length, as in *Calla;* at others its summit is naked, as in *Caladium:* it is branched in the Palms.

Besides these modifications of the structure of spikes, to which it is thought fit to give particular names, they also differ from one another:—1st. In the distance of the flowers, or the length of the internodes; thus, the flowers are very close in *Plantago lanceolata,* and very distant in *P. sparsiflora;* frequently the lower ones are more distant than the upper *(spica basi interrupta).* 2d. In the relative position of the flowers: opposite, as in *Crucianella;* verticillate, as in *Myriophyllum;* distichous, as in *Gladiolus;* or in a simple, double, or multiple spire; characters always connected with the disposition of the leaves. 3d. In the size and nature of the bracts; when these are large and foliaceous, the spike is leafy *(spica foliosa).* 4. In the form of the central axis, or rachis; which may be cylindrical, compressed, angular, or marked with depressions, in which the flowers are as it were inserted. 5. In the general form, which is usually cylindrical or conical, but sometimes oval or globular, and then it may be confounded with the capitate flowers, of which we shall afterwards speak.

2d. The Raceme *(racemus)* only differs from the spike in having longer pedicels, arising from the axils

of bracts. In general those at the base of the raceme, being older and more nourished, are the longest, and they diminish in size as they approach the top. The inverse takes place in a small number of cases; thus, for example, in *Hyacinthus comosus* the upper flowers are sterile, with their pedicels coloured and very long, forming a bunch or crown at the top of the raceme. All the differences which we have just now seen found in spikes when compared together, are also met with in racemes, but without having any particular names. We shall only say a few words on those which seem sufficiently important to deserve special names.

We have already said that those racemes are called compound, or branched, which are formed by the union of several partial ones into one inflorescence. When these, or their partial branches, are very long, much branched, and diffuse, the name of PANICLE *(panicula)* is given to them collectively; for example, in *Kœlreuteria.* If the axis be very short, and the branches very long and diffuse, as is seen in *Juncus,* the inflorescence has been designated by the name of ANTHELA.

It sometimes happens in a simple raceme that the lower pedicels are very long, and the upper very short, whence it results that the flowers, although springing from different points, nearly reach the same level. This kind of raceme, confounded with other very different inflorescences, has received the name of CORYMB *(corymbus)*; the *Ornithogalum,* said to be umbellate, and some species of *Iberis,* are examples of this.

The same thing may happen in compound racemes, either because the lower lateral branches or racemes are longer than the upper, or because each of them, considered separately, presents the same phenomenon, as to the length of its pedicel; this disposition is observed in *Viburnum,* the Elder, &c.; to this also the name of

Corymb is given, and when it is wished to distinguish it from the preceding, we may, from analogy with the racemes, of which they are modifications, designate the first by the name of a SINGLE CORYMB, and the second by that of COMPOUND CORYMB. But as several very distinct inflorescences have been confounded under the name of Corymb, I have reserved this name for a particular class, which we will shortly examine, and I shall designate by the name of SIMPLE CORYMBIFORM RACEME, simple racemes, with the flowers placed on the same level, and by that of COMPOUND CORYMBIFORM RACEME, those which being compound present nearly the same disposition. The reasons for this manner of speaking will become evident when we treat of true corymbs.

3d. The inflorescence in appearance the most distant from the raceme, is the UMBEL *(umbella)*. This name is given to an assemblage of one-flowered pedicels, which all spring exactly from the summit of a branch, or common peduncle. We distinguish the SIMPLE UMBEL, as, for example, in the Cowslip or cultivated Cherry; and the COMPOUND UMBEL, which exists in almost all the Umbelliferæ—it differs from the simple umbel in its common peduncles being themselves disposed in umbels; we here distinguish consequently the GENERAL or UNIVERSAL UMBEL, which is formed by the peduncles, and the PARTIAL UMBEL, or UMBELLULE, which is formed by the pedicels. The umbel really differs less from the raceme than it seems at first sight. If we compare, in fact, the different racemes together, we shall find some, it is true, which have the axis very long, as in the *Ornithogalum* of the Pyrenees; but some are also found with the axis much shorter, as in the *Ornithogalum* said to be umbellate, which has its flowers really in a raceme; lastly, we see racemes, the

axis of which is so short that all the pedicles might appear to spring from the summit, as in the Candytuft *(Iberis)*; and thus on comparing the corymbiform raceme, we come to consider that the latter is a raceme, the axis of which is wanting, or nearly so. I shall, perhaps, be better understood by a rude metaphor. Let us suppose a floral branch formed as a telescope, which bears a pedicel above each of the tubes of which it is composed; when all the tubes are pulled out and lengthened we have a raceme: let us push them half way back, it will still be a raceme, but very short; let us shut them up completely, and we shall have a terminal umbel. When we compare together the inflorescences of *Eryngium* and other Umbelliferæ, &c., it is difficult not to see this extreme analogy of umbels, with racemes with a short axis. This analogy is also remarkable in another respect; at the base of each pedicel of an umbel is found in general a bract, or small leaf, and another is found at the base of the peduncles of the general umbel: thus, in this case, as in those we have above analyzed, it is true to say, that the pedicels arise from the axil of a leaf, and that the compound inflorescences are formed by floral branches, which also arise from the axils of their proper leaves.

4th. Botanists have confounded, under the name of Capitulum, or Head, several inflorescences in reality very different, and which present nothing in common but very close flowers, either with the pedicels absent or very short. Rœper has begun to give some exactness to this incongruous assemblage, distinguishing the glomerule, of which we shall speak under definite inflorescences, and the capitulum, which makes part of the indefinite ones. We may also even say that under the name of capitulum we unite a particular state of each of the preceding inflorescences.

Thus, when a spiked flower, instead of having the axis elongated, is found to have an oval or globular one, and as the flowers are very close around it, there results an oval or globular spike which has often been called capitulum; such are the head of flowers of the Plane-tree, *Conocarpus*, &c., the female heads of *Sparganium*, the globular spikes of several Plantains, and some species of *Phyteuma*, &c.

When a raceme presents a very short axis, with numerous flowers, and very short pedicels, there may result from this union of circumstances a kind of globular head or capitulum; this happens in *Cephalanthus*. Likewise when an umbel has its pedicels very short and its flowers very compact, it may resemble a true capitulum; this happens in several species of *Œnanthe*.

Capitula differ principally from one another in the form of the axis: this is sometimes more or less elongated, as in the examples mentioned as being derived from the spike, sometimes it is short and more or less expanded, as in those which appear to be derived from the corymbiform raceme, or the umbel; but all intermediate degrees are found in the same families, such as the Dipsaceæ for example. When the axis is reduced to a disc, much expanded, the name of RECEPTACLE, PHORANTH, or CLINANTH, is given to it, and then the inflorescence receives that of ANTHODIUM or CALATHIDE; but although the terms to designate this kind of inflorescence peculiar to the Compositæ, and some neighbouring groups, have been multiplied, it would be difficult to establish a definition which would separate those inflorescences from other capitula. The conical receptacle in *Anthemis*, the oval one in *Sphæranthus*, and the oblong one in *Rudbeckia*, approach the elongated ones of the capitula of *Eryngium* and *Phyteuma*, whilst the flat ones of the Artichoke and Thistle would seem

analogous to the discs which support the partial flowers of the Umbelliferæ.

In all the inflorescences which we have enumerated the law of expansion is simple and uniform; everywhere the lower and external flowers open first; and the flowering proceeds consequently from the base upwards in the spike and raceme, and from without inwards in the corymbiform racemes and the umbel; it proceeds from the base upwards in the spiciform or elongated capitula, and from without inwards in the flat ones. This regular progress of the expansion Rœper has called by the name of CENTRIPETAL. It must, however, be remarked that, as regards compound spikes or racemes, the central axis, which is the prolongation of the stem or principal branch, flowers before the lateral ones, each of which follows in its turn its development in the same direction. The only exception which I know to this mode of development, is that which certain Dipsaceæ present, the flowering of which often commences in the middle of the spike: this anomaly must be connected with some peculiarity in the vegetation of these plants; for, as to their form, they cannot be separated from centripetal inflorescences, and this mode is presented regularly in the other species of the family.

Some of the inflorescences which have been enumerated in this section may be combined together. Thus, the flowers of the Gramineæ are, as we have said, disposed in small distichous spikes, which have been called spikelets; and these, more or less pedicellate, are disposed in panicles, sometimes very lax, at others more or less compact; the flowers of *Carex* are disposed in close spikes, which are arranged in a raceme along the central axis; those of *Papyrus* are disposed in spikelets, which are pedunculate and arranged in an umbel at the top of the stem; the flowers in

Juncus and others are frequently found in capitula, which are disposed in a contracted panicle. Thus may not only these primitive dispositions be either simple or branching, but the branch itself may present a disposition sometimes resembling, at others differing from, that of the central axis.

A second difference which goes to prove the little real importance of these divisions, in appearance so distinct, is, that it happens in plants with separate sexes that the male and female flowers often present different dispositions; thus, the male flowers of the Indian Corn are in branching spikes, the female in simple ones; the males of the Fir in catkins, the females in cones; the males of the Hop in panicles, the females in a kind of cone or spike; the flowers of *Hura crepitans*, although springing from the same axil, are disposed in two manners,—the females solitary, the males in a spike, &c. Generally, in all cases of inequality of the two sexes, the male flowers are more scattered and with longer pedicels, and the female more sessile and compact.

Section III.

Of Terminal Inflorescences, or those with a Centrifugal Evolution.

In this second class of inflorescence, the stem or principal branch, instead of being prolonged indefinitely in a straight line, and only bearing the flowers laterally, is found terminated by a flower, which, instead of arising from the axil of a bract, is found to have at the base of its pedicel two opposite, and sometimes several verticil-

late bracts. Let us examine the first case on account of its greater simplicity.

In the axil of each of the two bracts there may arise a branch, which, as happens in the primitive one, is found in the same manner terminated by a flower with two bracts, which, in their turn, may produce two branches, and thus indefinitely. There results from this disposition a series of bifurcations, in the centre of each of which is found a solitary flower: the inflorescence in this sense is terminal, since each flower terminates its branch; it is indefinite in this respect—that each branch may, from the axils of the two bracts, give birth to new branches, which enjoy the same faculty; whence it results, that in this case, as in the preceding, there is no limit to the elongation of the plant and the development of flowers, except by the exhaustion produced either by the paucity of nourishment or the greediness of the floral organs. We designate under the collective name of CYME *(cyma)* all the inflorescences of this kind; calling those DICHOTOMOUS CYMES, where the flower is provided with two bracts, and where the branches go on bifurcating without cessation; this is most frequently the case in Dicotyledons; for example, in *Erythræa*, *Kalanchoe*, most Caryophylleæ, &c. In the same manner we call cymes TRICHOTOMOUS, TETRACHOTOMOUS, PENTACHOTOMOUS, &c. where each terminal flower has under it three, four, or five bracts which give birth to as many branches; the Euphorbiums present examples. Sometimes, in these different systems, the central flower is abortive, and thus we might at first sight confound them with umbels or compound corymbiform racemes: the order of evolution, which will engage our attention presently, is sufficient to remove this doubt; here the central flowers, or those which terminate the branch, expand first, whilst, in

corymbiform racemes and umbels, the lateral ones are the first to expand.

A second remarkable difference which is observed in cymes, especially in dichotomous ones, is, that of the two branches which ought to be developed in the axils of the two bracts, one is sometimes abortive, and then the terminal flower seems lateral; this is very clearly observed on comparing the Silenes said to have spiked flowers, with those with an evidently dichotomous inflorescence. In this case the flowers are generally disposed upon only one side, either by a tendency of the branches to be abortive on that side, or by a torsion of the axis. The branches or stems in which this disposition takes place are in general, before their development, rolled up: this is observed in *Drosera*, the cymes of which have the flowers unilateral; in the Silenes, said to be spiked; in the branches of the cymes of *Sedum;* in those of *Echium*, and other Boragineæ. I give to these cymes, the flowers of which seem unilateral, the name of Scorpioid Cymes, which makes allusion to their mode of development.

The different dispositions of cymes of which we have spoken, may be combined together; thus, several species of *Sedum* present a general cyme, the central flower of which is abortive, and which is divided into several lateral branches, some of them dichotomous at the base, others simple, and with unilateral flowers, on account of the abortion of the secondary ramuscules. When a cyme has the lateral branches very short, the flowers are found agglomerated together; this is seen, for example, in the Sweet-William. Rœper gives to this disposition the particular name of Fascicle *(fasciculus)*, which, on acount of its vague nature, is found applied by different writers to other dispositions of flowers. That of Contracted Cyme *(cyma contracta)* would

possess some advantage, in my opinion, because it would make known the nature as well as the appearance of this disposition.

Lastly, the same naturalist proposes to call GLOMERULE *(glomerulus)* those cymes which are so contracted that their ramification is scarcely apparent, appearing at first sight to be true capitula; but they differ, because the flowering commences at the centre instead of the circumference. This disposition, less frequent than that of true capitula, is observed in *Corymbium* and some other Compositæ. *Cardopatum* and the Euphorbiums have the flowers in glomerules which are disposed in cymes.

In all the inflorescences which I have pointed out, the central flower of each ramification always expands before those which terminate the branches situated above it; so that, where the flowers are near together in a fascicle or glomerule, or corymbiform or umbelliform cyme, the flowering proceeds from the centre to the circumference, and the evolution, for this reason, has been called CENTRIFUGAL by Rœper.

When centrifugal inflorescences are reduced to a single flower, it seems impossible to distinguish them from the one-flowered pedicels of indefinite inflorescences; but there are almost always means of recognising them; and, in particular, the pedicels of the indefinite have only one bract at their base; those of terminal inflorescences have two opposite ones, and sometimes a third lateral one, when the cymes themselves arise from its axil.

Notwithstanding the extreme difference which is found between the two systems we have explained, there are numerous cases where the two modes are combined in the same plants; we now proceed to examine this in the following section under the name of Mixed Inflorescences.

Section IV.

Of Mixed Inflorescences, or those which partake of the two preceding.

Inflorescences may be mixed after two different systems; viz. either, 1st, because the central axis proceeds in the manner of indefinite inflorescences, and the lateral branches follow the progress of terminal ones; or 2d, because the central axis proceeds in the manner of terminal inflorescences, and the lateral branches follow the progress of indefinite ones.

To the first of these divisions belong the true Thyrses; to the second, the true Corymbs. Let us examine the modifications of these two inflorescences, and their particular affinities with the two preceding classes.

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§ 1.—Of Thyrses.

If I examine one of the Labiatæ, I see that the stem or branch is prolonged indefinitely by its extremity, and that the pairs of leaves may be there developed successively, one after the other, without any other natural termination than that of the vegetation; all the inflorescences proceed from the axils of the leaves, and each is a di- or trichotomous cyme. Thus, the whole inflorescence of the Labiatæ is a Thyrse, interrupted by the distance of the internodes and the great development of the leaves from the axils of which the cymes are developed. When these cymes are very lax, this disposition is very evident; when they are close and compact, so as to form axillary fascicles, the union then of two

opposite ones forms a kind of ring or false verticil around the stem; and for this reason the Labiatæ have been frequently confounded with true verticillate flowers, which are very rare in nature. It sometimes happens that the cymes of the Labiatæ are composed of a very small number of flowers; they may even be reduced to one, without the fundamental type of the inflorescence being altered; for in this case the floral pedicule presents two opposite bracteoles, from the centre of which rises the proper pedicel, and from the axils of which ought to proceed the lateral ramuscules. It happens in some Labiatæ that the cymes only arise from the upper axils; then the leaves are reduced to the state of bracts, and the internodes are much shortened. These phenomena cause the continuous thyrse to be rather compact, sometimes in the form of a raceme, as in *Clinopodium;* at others, in that of a spike, as in *Lavandula.* In these racemiform or spiciform thyrses, it sometimes happens that the upper branches cease to bear flowers, are more or less coloured, increase much in size, and form at the summit of the thyrse a bunch, which recalls to mind that of *Eucomis:* this is observed in *Salvia Horminum, Lavandula stœchas,* &c.

All that I have said of the Labiatæ is equally applicable to the Lythrariæ, in which are found sometimes, as in *Ammannia,* lax lateral cymes; sometimes, as in *Lythrum,* short ones, which collectively resemble either a terminal spike *(Salicariæ)* or simple axillary flowers (*Hyssopifoliæ*).

The comparison of the species of *Eugenia* together presents a clear example of the apparent modifications which may result from the system of interrupted thyrses. We here find species which seem to have a simple one-flowered pedicel; but this apparent pedicel bears two opposite bracteoles, and it ought to be considered as a

pedicule, from the apex of which proceeds a terminal flower, and frequently two lateral branches from the axils of the bracteoles: when these branches are developed, the cyme is bifid and three-flowered; when subsequent ramifications take place, then a true di- or trichotomous cyme is formed. If, however, this last state takes place towards the top of the branches, as the leaves may be but little developed, the internodes near together, and the principal stem but slightly disposed to elongate, then the union of these lateral cymes forms what is called a terminal panicle, which is only a true thyrse, with ramified branches, or a PANICULIFORM THYRSE.

The example of the thyrse of *Eugenia* leads us to understand several inflorescences which resemble also racemes or panicles; such are the thyrses of the Lilac. Here the floral branch only bears at its base a small number of leaves; the axis elongates after the system of indefinite inflorescence; and the lateral branches (in the axils of leaves reduced to the state of very small bracts) are true cymes, the union of which forms a thyrse: this also happens in the Vine, &c.

Several Leguminosæ present analogous phenomena; thus, there is a great number of species where we see racemes apparently simple and resembling true ones; they resemble them, in fact, by the possibility of indefinite elongation, and the axillary position of the peduncles; but each peduncle bears two opposite bracts, from which arise either only a terminal pedicel, or one with lateral ramuscules; thus, in all these plants, the raceme is in appearance almost indifferently simple or branched, and ought to be considered as a true RACEMIFORM THYRSE.

Several Monocotyledons are found, which, it is said, have their flowers in spikes, with three bracts at the

base of each flower—as *Pitcairnia.* Of these bracts, the lower one represents the true leaf; the two others are the bracteoles of a very short peduncle, and the whole forms a Spiciform Thyrse. In neighbouring species we see these peduncles elongated into true cymes.

Lastly, we have seen, in speaking of Cymes, that their branches seem, from the abortion of one of them, to bear lateral flowers: when this phenomenon is combined with that which I have mentioned, there results a singular kind of inflorescence, which may be seen in the woody kinds of *Echium;* the axis lengthens indefinitely by its summit, and bears branches laterally, which arise from the axils of leaves changed into bracts. These branches are true cymes, reduced by abortion to only their terminal flowers which appear lateral, or scorpioid cymes; the whole then is a thyrse with scorpioid cymes, or, if we wish, for the sake of abbreviation, a Scorpioid Thyrse.

Thus, Thyrses are systems of inflorescence, of which, 1st, the central axis follows the laws of indefinite inflorescence, and may present all its modifications, such as the states of spikes, elongated corymbiform racemes, umbels, &c.; and of which, 2d, the lateral branches follow the laws of terminal inflorescence, and may present all its modifications, viz. the state of dichotomous, trichotomous, scorpioid cymes, fascicles, and glomerules. The evolution of these two systems follows the laws of each:—the development of the central axis and its parts proceeds from the base upwards; that of each of the lateral branches commences at the centre and follows a centrifugal course.

§ 2.—Of Corymbs.

The inverse to all that we have yet observed takes place in the Corymb (*corymbus*). This term has hitherto, in all the writings of botanists, been used in a vague sense, and solely founded upon appearance. I propose to limit it to a very distinct case, which deserves a special name, viz. the case of inflorescences where the central axis follows the laws of terminal inflorescence, and the lateral branches, that of indefinite; almost all the Compositæ are examples of this system, and the name of Corymbiferæ has for this reason been given to several of them. If we follow the development of *Tolpis*, or of most of the Compositæ, we see that the central axis terminates in a capitulum, and that the lateral branches are developed in a centrifugal order; those which are nearest the central capitulum (which may be here provisionally considered as a flower) expand first; but all these successive capitula, which, compared together, follow the centrifugal evolution, are individually subject to the laws of the centripetal, in each of them the expansion of the flowers proceeding from the circumference to the centre. When the corymbs are very near together, as, for example, in *Cardopatum*, the expansion appears perfectly irregular, because the flowers of each capitulum, or the capitula of the whole corymb, follow two different systems of evolution. When the partial capitula are reduced to a single flower, the whole evolution is centrifugal, in which this head, composed of capitula, differs much from true capitula; this happens in *Echinops*. When the capitula are solitary, or, in other terms, when the lateral branches are not developed, the single capitulum flowers after the system of indefinite inflorescence alone, and then the head of a monocephalous compound flower does not differ from that of other flowers in capitula.

Section V.

Of Anomalous Inflorescences, or those which seem to form an exception to the preceding laws.

The general systems of inflorescence which we have examined in the three preceding sections, might appear to include all phanerogamous plants, but there are some which form an exception to the general laws; such are the inflorescences said to be opposite the leaves, radical, extra-axillary, petiolary, epiphyllous ones, or those which are modified by unions, abortions or degenerations.

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§ 1.—Inflorescences opposite the Leaves.

Inflorescences opposite the leaves appear to be always formed by the real top of the stem. One may be convinced of this by the following considerations :—

A leaf provided with its axillary bud may be considered as the point of departure, or origin of two distinct productions:—1st, a bud, which may be developed into branches with leaves or flowers; 2d, the branch, which is the prolongation of the same stem which bears the leaf. Two things may happen in the development of these bodies; the one which is the most simple, is that the continuation of the stem is stronger and more vigorous and forward than the axillary bud, which then developing after the other, and weaker than it, always retains the lateral position, and forms, consequently, an axillary branch if it have only leaves, or an axillary inflorescence if it have flowers; this latter is most frequently the case, and we have examined it in § 2, 3,

and 4. The other, which takes place in a smaller number of plants, is that where the axillary bud grows so powerfully and rapidly as to cause two appearances at once, viz. that it resembles the continuation of the stem, and that the true stem is pushed to the side opposite the leaf. In this state of things, less rare than is imagined, two different cases happen, either by the more or less forward disposition of each of these organs, or by their place upon the stem.

1st. Sometimes the axillary bud, thus developed into a branch which seems terminal, receives such strength as to flower first, attracts all the juices, and then the real summit of the stem, thrown on one side under the form of a branch, becomes abortive, and perishes. In this case the raceme which is formed, although really axillary, is said to be terminal; it is this which takes place in several Cruciferæ.

2d. Sometimes the axillary bud, developed into a branch and replacing the stem, has less tendency than the latter to flower; and then this top of the stem, pushed on the side opposite the leaf, absorbs proportionally sufficient juice to sustain it, and begins to flower under the form of an inflorescence opposite the leaf. All who will follow the development of the flowers opposite the leaves in the Cruciferæ, Umbelliferæ, Leguminosæ, and, in general, in all plants with alternate leaves, will, I think, be convinced that it is in this manner that the phenomenon takes place. They will even be able to give an easy account of the details of the phenomenon; thus one may understand by this theory, why the stem is often bent in a zigzag manner in the species where the inflorescences are opposite the leaves.

3d. When the fact which I have just mentioned takes place at the bottom of the plant, neither the axillary bud nor the stem itself being disposed to flower, it only

results from the rapid growth of the bud, that the true stem takes the appearance of a branch opposite the leaf; and if the two productions have an equal degree of development, the stem is said to be forked, or, when the same phenomenon is frequently repeated, dichotomous.

4th. When it takes place towards the top of the plant, and the two productions have nearly an equal force, or an equal disposition to flower; then, according to circumstances often very slight, the inflorescence seems either terminal or opposite the leaves; and this explains why, in the descriptions of different authors, we so frequently find these two expressions taken the one for the other, especially in the families which I have mentioned.

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§ 2.—Radical Inflorescences.

Flowers are said to be radical when they seem to spring from the root: but this term ought only to be taken as a simple metaphor; for the inflorescence never arises anywhere but from the stem. Pedicels having a single flower, or floral branches, which bear several, are said to be radical in some cases; viz. sometimes, when the stem is very evident, these pedicels arise from the lower axils only, as in *Vinca herbacea;* sometimes, when it is so short and level with the surface that it is with difficulty distinguished from the root, as in *Mandragora*, the leaves are very near the neck, and the peduncles arise from their axils; sometimes, when the stem is entirely subterranean, the leaves are reduced to the state of scales, either fleshy or scarious, and the peduncles which spring from their axils proceed from the earth, as if the root gave birth to them (we see this in

bulbous plants); sometimes, finally, the stem, although long, is buried under the earth or water, and produces true leaves, which have, as usual, axillary peduncles; this takes place in *Nymphæa, Utricularia*, &c. Thus the various flowers said to be radical do not differ from ordinary ones as to their anatomical origin.

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§ 3.—Lateral, or Extra-axillary Inflorescences.

It is usually said, that flowers are lateral, supra-axillary, or extra-axillary, when they seem to arise from the stem beyond the axils of the leaves. This phenomenon ought to be referred to two classes: sometimes, as in *Solanum*, it is a true anomalous development, analogous to that which renders their leaves geminate: sometimes it is a simple case of union; the peduncle which arises from the axil is sometimes intimately connected with the branch which gives birth to it; then the flower or flowers which it bears seem, according to their direction, to arise from the branch at the point where the junction terminates: examples of this phenomenon are found in different families, but it nowhere presents a more singular appearance than in a small section of *Capparis* (*Capparides seriales*), where the flowers are arranged three, four, or five, in succession, in a longitudinal series above the flower (Pl. 16, fig. 2); this is a unilateral spike adherent to the branch.

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§ 4.—Petiolary Inflorescences.

Flowers are said to be petiolary when they spring from the petiole of the leaf: this illusion takes place in two cases, viz. with regard to the petioles of simple leaves, and those of compound ones.

The first is also a case of union, the inverse of the preceding. The peduncle which arises from the axil unites sometimes with the petiole, and then the flower or flowers which it bears seem to arise from the petiole at the point where the union ceases; this is very visible in *Chailletia*, where the flowers are upon the same branches, sometimes evidently axillary or petiolary, according as the peduncle is free or adherent to the petiole; it is also remarked more or less constantly in several species of *Hibiscus*. The union, on the contrary, is constant in *Tapura*, for example, and several others. The position of the flowers of *Thesium* may result from the union of the pedicel with the leaf or petiole.

The second example of petiolary flowers is that of those which spring, it is said, from the common petioles of pinnate leaves; as, for example, in several species of *Phyllanthus*. These flowers always arise from the axils of the organs which are called leaflets, when the axis receives the name of petiole; but the truth is, that what is called a compound leaf is a branch with alternate leaves, and consequently the flowers are axillary as usual. What is remarkable in this kind of branches (which Martius has happily designated by the name of *Rami pinnæformes*) is, that their base is articulated with the stem. The *Zizyphus*, after some years, elucidates the nature of these branches which resemble leaves: when an old one is observed, we see here and there kinds of thick knots, from which arise eight or ten small branches in a bundle; each of these is simple, and bears alternate leaves, and frequently flowers, in its axil: in the autumn, a part of these branches disarticulate and fall off, whilst some remain and become true persistent branches which are not capable of being disarticulated. It is impossible for any one to have followed the vege-

tation of this plant without seeing the truth of what I have just set forth; and I have concluded that it must be the same in those species of *Phyllanthus* said to have pinnate leaves. The manner in which Martius describes those which he has observed, proves that he has arrived at the same results, and that consequently the pretended flower-bearing leaflets of these plants are penniform branches. The observation of *Phyllanthus Cochinchinensis* in a living state has confirmed my opinion: this case then enters into the general law of axillary flowers.

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§ 5.—Epiphylious Inflorescences.

Flowers are said to be Epiphyllous, or arising from the leaves, in four cases: the first, which enters into one of the preceding, is where the peduncle is very intimately united along the petiole (if it exist), and the middle nerve of the leaf, so that the flowers appear to arise from the limb at the point where the union ceases: this is what seems to take place in *Polycardia*, where the union takes place as far as the top of the middle nerve; in these cases, if the peduncle bear any bracts at its apex, the flowers seem to arise from a disc of the leaf.

The second case deserves this name still less; it is where the floral branches are large, dilated, green, and flattened in the form of leaves; we see this, for example, in *Xylophylla* (Pl. 16, fig. 1) and *Opuntia*; but it is so true that these bodies which bear the flowers are branches and not leaves, that when their subsequent development is followed, they are seen to change gradually into cylindrical branches, furnished with others like what they themselves originally were.

The third case is that which *Moræa Northiana* presents, the flowers of which are said to spring from the edge of the leaf; but this is also an example of the necessity of distinguished primitive and modified forms: this *Moræa* has, like all the others, a peduncle furnished with flowers, but it is surrounded as far as the origin of the flowers by a leaf folded upon itself, and which surrounds it so closely that the flowers seem to proceed from it. *Zostera* presents in the same manner a leaf folded lengthways, and the flowers spring from a peduncle united to this folded leaf.

The fourth case is that of *Ruscus*, which seems to owe its appearance to its leaves arising from foliiform branches of an entirely peculiar form; when the development of a young plant is followed (Pl. 16, fig. 3), we see that the true leaves, as in the Asparagi, are caducous and slightly embracing scales, whilst the very compressed organs which spring from their axil are true branches which are destined to bear flowers. In some species, as in *R. Hypoglossum*, this foliiform branch bears, besides flowers, a true floral leaf, the presence of which confirms the nature of the branch.

Section VI.

Of Pedicels and Peduncles.

It is usual to designate under the special name of Pedicel *(pedicellus)* the immediate support of each flower; and to reserve those of Pedicule or Peduncle *(pediculus, pedunculus)* for all the ramifications of the

general axis, or rachis. It evidently results from the ideas contained in the preceding Section, that the pedicel ought in fact to be considered as a proper organ; but that the axis, and all the ramifications of compound inflorescences, except the pedicels, can only be considered as floral branches. However, in order to conform to usage, and to avoid circumlocution, I shall employ the words Pedicule and Rachis, in their ordinary sense. I have already explained that which relates to the general distribution of these pedicels; it now remains to examine their forms, articulation, and history.

Pedicels, properly so called, are always terminated by a single flower; unless two be joined together, as in several Honeysuckles, and then an apparently single one seems to bear two flowers or fruits. These supports are in general either strictly cylindrical, or a little expanded into a reversed cone below the origin of the flower, or slightly compressed. Their length is sometimes very considerable; it is described either in reference to that of the calyx or flower, or in comparison with the size of the bract or leaf, from the axil of which it proceeds. When it is so short that no interval between the axil and the flower can be distinguished, the latter is said to be sessile, or to have the pedicel wanting; but we may say that in reality it always exists, although sometimes hardly visible; and consequently this character is uncertain, as are all those which relate to the degree of development: it very frequently happens that, in the same species, often in the same inflorescence, either in different places or at different ages, the pedicels are either so long as to be distinct, or apparently entirely wanting.

The Pedicules present in general more varieties of form than pedicels; for, independently of those which are common to both, there are several others which

depend either upon the mode of inflorescence, or upon what we confound under the name of peduncle—the several different degrees of the ramifications. In general they present a more cylindrical form in racemes and spikes, and have a tendency to dilate at the top in umbels.

In the former, the principal difference which they present is that of being either really cylindrical, or more or less compressed; this compression in some cases, goes so far as to give them a form, expanded into a strap, as in certain species of *Eugenia* and *Eucalyptus*.

Sometimes this strap-like form appears peculiar to the species, without our being able to determine the cause :—sometimes it seems to result from the compression of neighbouring organs; thus the peduncles which proceed from several bulbs are compressed, at least at their base, by the pressure of the coats: sometimes it appears to be owing to the peduncle being bordered by a foliaceous membrane; this seems to take place in *Ruscus*, and more evidently in *Urtica membranacea;* in this case the flowers arise from the middle of the membrane which represents the true pedicule. Sometimes the compression is owing to a kind of dilatation or foliaceous expansion of the peduncle, as in *Xylophylla* (Pl. 16, fig. 1). When the peduncles are much compressed, the pedicels usually arise from the angles, and not from the plane surfaces—for example, in *Xylophylla;* whence it results that they strictly alternate, and if they are near together their flowers are said to be distichous.

In umbels, or umbelliferous cymes, the peduncles have a tendency to be dilated at the summit; and this is connected with two circumstances: it is large in proportion as the number of flowers which ought to be found placed upon the peduncle is large; it is also generally larger

in proportion as the flowers are more nearly being sessile upon the horizontal expansion produced by it. This expansion bears the name of the RECEPTACLE of the flowers *(receptaculum)*; some have given it the name of PHORANTH or CLINANTH.

When the flowers are not numerous, as in di- or trichotomous inflorescences, or when they are provided with distinct pedicels, as in most Umbelliferæ, the receptacle then differs so little from the other parts of the ramifications, that this name is but seldom applied to it; but in this case, as in those where it is more evident, the receptacle or common point of departure of the branches of an umbel, is a more or less dilated portion, in which is deposited, before the flowering, a certain quantity of nutritive matter, which serves for the further development of the flowers or fruits. All many-flowered receptacles are likewise generally very thick and fleshy. This deposition of nutriment which is stored up for the flowers, is appropriated by men and animals for their own use; thus we take the receptacles of the Fig, the Artichoke, and other syngenesious plants, precisely for the same reason which makes us select tubercules and fleshy cotyledons, because we find in them a deposition of nutriment; thus a great number of insects establish themselves in the receptacles of capitulate or umbellate flowers, because they not only find there a shelter, but also abundant nutriment. When insects attack them (and floriculturists know that this is but too frequent,) they always direct their efforts at the point of departure of the rays, which represents the receptacle, and which contains the store of nourishment intended for the flowering.

The covered receptacles of sessile flowers are of a whitish colour, being etiolated by their being shaded from the light; before flowering they are in general

rather thick, and become thinner, or at least part with a considerable portion of their store, during that period; therefore care is taken to select those for culinary purposes before this takes place. Those of the Chicoraceæ empty themselves very early; those of the Cinarocephalæ remain a longer time fleshy, but at maturity they only present a tissue resembling an empty pith; in some the inverse takes place, as in the Fig, which becomes fleshy on approaching maturity. It is, perhaps, worthy of remark, that in all plants with milky juice, the receptacle, at the period of flowering, is full of a juice of a different nature; thus the Fig, and the receptacles of all the milky Compositæ, are filled with this juice before flowering, and cease to receive it or form it after that period has commenced.

The receptacles are sometimes in the form of a cylinder or elongated cone, as in the capitula of spiked flowers—*Dipsacus* and *Eryngium*, for example; sometimes in that of a short cone, or simply convex, as in a great number of Compositæ or Dipsaceæ; sometimes flat, or even slightly concave, as in most Compositæ and in *Dorstenia*. Sometimes the margins of the receptacle are elevated, and cover the flowers; we see this in *Dorstenia:* it is more decided in the Fig, where they enclose all the flowers in a kind of envelope, with a very small opening at the top.

At maturity, the receptacles undergo changes of form, which facilitate or cause the fall of the seeds. Flat or convex ones become raised in the centre, and thus throw off the seed; concave ones open by the reflection of their margins, as is seen in the Fig when left to itself, and still more in *Ambora*.

Peduncles which arise from a stock which is under ground, or on a level with the surface, have received the particular name of SCAPES *(scapi);* they only differ

from ordinary branches in their never bearing true leaves, but only bracts or floral ones; thus the scape which supports the head of flowers of the Daisy, or the solitary one of the *Cyclamen*, or the spike of the Plantain, is entirely devoid of true leaves.

Pedicels and pedicules are often furnished with articulations, the study of which presents some interest, both on account of their causing the fall of fruits, and because they elucidate the true structure of the organs of inflorescence.

Pedicels often appear articulated in the middle of their length; but it must be remarked that when this phenomenon takes place, either near the base or apex, or really at the middle, we observe below the articulation two small bracts; which indicates that we ought to consider as terminal or compound inflorescences, the cases where such articulations are found, and to reserve the name of pedicel for the part above it, and which bears the flower. What tends to confirm this opinion is, that it happens in a great number of plants—several Myrtaceæ, Leguminosæ, &c. for example—that where such an articulation is found, a second or third pedicel is seen to spring from it, proving that the lower portion is a true pedicule, and not a part of the pedicel. In the same manner we here and there meet with articulations in different parts of the system in compound inflorescences; but what is more remarkable is, that sometimes the floral branch itself is articulated at its base: this is what is observed in the spikes or racemes of several Amentaceæ, to which the particular name of CATKIN *(amentum)* has been given—a name which, from analogy in form, has been sometimes extended to the spikes or racemes of some species of these families where the articulation does not exist. We meet with this articulation, and consequently the fall of the

entire system of flowers or fruits, in the Mulberry, Fig, &c.

The study of the vegetation of the pedicules and pedicels forms a part of physiology rather than of Organography: I shall limit myself to remarking here—

1st. That we frequently see them take different and fixed directions before, during, and after flowering: in general they spring upright, and fall as they advance in age; but different plants present in this respect very curious physiological phenomena.

2d. They also sometimes, on becoming old, alter their length in a very decided manner.

3. They also sometimes change in texture: thus, that of *Anacardium*, which bears the Cashew-nut, becomes so fleshy after flowering as to have nearly the form and size of a pear; that of the Fig is so pulpy as to be considered a true fruit. On the contrary, some remain and dry up after flowering, so as to take the appearance of true spines, as we see in *Mesembryanthemum spinosum*, *Alyssum spinosum*, &c.

4th. Some pedicules, when their flowers are abortive, are transformed into elongated processes, which are named Tendrils, and of which we shall speak in the next Book.

5. Some peduncles, especially among those which arise from near the neck, and which are called Scapes *(scapi)*, present a disposition to twist themselves in a regular spire, in a manner analogous to twining stems, and sometimes even more decided: this is observed in the scapes of *Cyclamen*, and in those which bear the female flowers of *Vallisneria*. These, as is well known, elongate so as to elevate the flower to the surface of the water, unrolling the turns of their spire; and contracting again after flowering, in order to bring back

the fruit to ripen at the bottom of the water. All that we have said of twining stems is applicable to these scapes.

Section VII.

Of Bracts.

Bracts, in general, are the leaves from the axil of which the floral branches, their ramifications, or even the pedicels themselves, proceed; they differ from ordinary leaves in form, size, colour, &c. or, at least, what is more constant, in their not bearing true buds in their axils, the flowers replacing them.

That bracts are only leaves modified by their position, it is hardly necessary to endeavour to establish, seeing that the slightest inspection of them suffices to show it. This opinion is especially demonstrated by frequent cases where the bracts change into true leaves, as happens in several Cruciferæ, Plantains, &c.

In simple inflorescences, such as the raceme of a Hyacinth, the pedicels all spring from the axils of bracts, and there is no difficulty in distinguishing these organs; but in compound racemes there are as many different orders of bracts as degrees of ramifications. The common name of bracts is given to all, except in one single case,—that where the last ramifications of a compound inflorescence bear pedicules terminated by a single pedicel, or, as is commonly said, when the pedicels are articulated in their length; then the little bracts which are found at this articulation are sometimes called Bracteoles. This distinction is not strict, but it is

convenient in practice for avoiding long circumlocutions.

Bracts are, as we have said, leaves modified by the production of flowers, which, developing in their axil, attract a great part of the sap; whence it results that they are in general smaller, less divided, and more membranous than the leaves of the plant. Frequently they participate, as well as the pedicels, in the colour of the flower, as is seen in *Hortensia*, (of which that which is commonly called the flower, is essentially formed of coloured bracts,) in *Salvia splendens*, *Melampyrum*, &c. The last presents the double singularity of the coloured bracts being larger and more divided than the leaves.

The colouring of bracts takes place the more readily, in proportion as they are nearer the flowers. When the leaves of the plant are compound, the bracts of the first ramifications are sometimes so likewise, but most frequently they are reduced to simple scales resembling the rudiment of a petiole.

Bracts are often triple or trifid; and in this case the two lateral ones, or the two lateral lobes of a bract apparently single, are rudiments of stipules: thus, in plants where the stipules are distinct from the petiole, we frequently find, at the base either of the floral branches or of the pedicels, three distinct bracts, the two lateral being the smaller. In plants where the stipules are adherent to the petiole, we frequently find bracts with three lobes: sometimes the stipules retain, in this state of bracts, a large development, and the true leaf is either entirely or partly abortive; the bract is then replaced by two lateral and opposite ones, as is seen in *Cliffortia*, &c. This phenomenon is analogous to what takes place in *Lathyrus Aphaca*.

There are plants where the floral leaf, in being transformed into a bract, instead of taking a membranous and

foliaceous appearance, assumes either that of a spiny point, (as in *Barleria*, *Exoacantha*, &c.) or of a small tendrill, (as in some species of *Bauhinia*,) or of a tubercle or gland.

As long as the bracts are, by the disposition of the flowers, so separated from one another as not to form a ring or particular envelope, the name of bracts is applied to them; but they take another appearance when the near approach of the pedicels or peduncles compels the branches to arise in more or less regular verticils, as is seen in umbels, corymbs, and capitula; the name of INVOLUCRUM is then given to them collectively, and to each individually the names of Scale, Leaflet, or Bract.

In umbels, where the common pedicule is not dilated into a receptacle, the involucra are generally composed of as many bracts as there are rays in the umbel; and they are distributed in a single row.

In flowers in a compact head, the number of the leaflets of the involucrum is rarely fixed; they form around the flowers an envelope of one or several rows, which surround them so closely that it seems as if all the flowers of a head formed but one, the involucrum appearing to be a calyx.

The bracts which compose the involucra may be either verticillate in a single row *(uniseriales)*, or in two *(biseriales)*, or in several *(pluriseriales)*. When they are in two rows, and the outside one is perceptibly smaller, the involucrum is said to be CALICULATE, or furnished at its base with a kind of small calyx: when they are in several rows, and the outer ones cover over the base of the inner ones, gradually diminishing in size, the involucrum is said to be IMBRICATE. A singular mode of imbrication is accidentally presented in some Pinks: their flower, in the natural state, is furnished at the base with two pair of leaves reduced to the

state of bracts; but sometimes instead of two pair, we find fifteen or twenty imbricated, so as to form a kind of elongated spike, and in this case the flower is most frequently abortive. This monstrosity is called in gardens *Dianthus Caryophyllus imbricatus.*

The pieces which form the involucra, especially those in a single row, are sometimes perfectly free; this is most frequently the case: sometimes they are united by their margins, so as to resemble a single leaf; such are those of several kinds of *Bupleurum, Seseli Hippomarathrum, Othonna,* and *Nyctago.* These involucra are usually very inaccurately called monophyllous, which term ought to be replaced by that of GAMOPHYLLOUS, which expresses their true nature.

When the involucra enclose several flowers, there can be no doubt upon their nature; but when they enclose only one, it is often difficult to affirm if the envelope be an external calyx or an involucrum: this doubt is especially very great when the leaflets are united together, as the sepals of a calyx. Though in the Marvel of Peru the involucrum has been almost constantly taken for a calyx, we are assured that it is an involucrum, because in several plants of the same family this organ contains several flowers, which is never the case with a true calyx: the same illusion has also existed for a long time in the *Euphorbia,* where the involucrum has been called by the name of calyx, until it was known that what was thought to be a single flower was an assemblage of several in a head. We know now in the same manner that the spiny envelope of Chestnuts, the cupule of the Acorn, or Hazel-nut, are involucra, and not calyces. The question is more delicate in the Malvaceæ, which frequently bear, outside the calyx, a row of verticillate leaflets: some call them the external calyx, because they spring from the base of it. There

are some who have considered them as representing the stipules of the calycinal leaves: some believe them to be one-flowered involucra; founding this opinion upon the irregularity of their presence, number, position, and shape, which appears to indicate that they form part rather of the organs of inflorescence than of the flower, properly so called. The question will be resolved in the affirmative, if a Malvaceous plant should be found bearing more than one flower within this external covering.

The bracts which arise at the base of the partial umbels form what is called the PARTIAL INVOLUCRUM, or the INVOLUCELLUM: those which grow at the base of the peduncles, or general umbels, take the name of the GENERAL INVOLUCRUM. In flowers in heads, we frequently find one or more within a primary envelope; this is the involucellum: for example, in *Echinops* the involucellum is one-flowered, with several imbricated leaflets; and in *Lagasca* it is also one-flowered, but the leaflets are combined. These involucella, in the examples which I have mentioned, are collected into a compact head, which is itself surrounded by an involucrum, to which the name of General Involucrum, or the involucrum properly so called, is given, and they are themselves sometimes surrounded by others more external. There is in general but little exactness in the manner in which these parts are designated and compared together, and great errors in description frequently result.

In a great number of capitate flowers, we find, besides the scales of the involucrum, other bracts, situated between the flowers, and springing from the receptacle: the leaflets of the involucrum are analogous to the bracts which arise at the base of compound inflorescences; the scales of the receptacle represent the bracts belonging to

each flower, or the bracteoles; and what, among other circumstances, tends to prove the analogy of these organs is, that these scales are always situated on the outer side of each flower, which corresponds to the lower one of racemes, and consequently their position is the same as that of the bracteoles. When the gradations of form from the leaflets of the involucrum to the scales of the receptacles are carefully followed, no one can doubt the identity of these organs. As they are situated between very close flowers, it frequently happens that they are abortive; or reduced to a perfectly scaly state, and of very small dimensions; or, lastly, they are united either with each other, or with the flower. When they are united together by their margins, it results that each flower seems as if it were inserted into a little cup; this is observed very well in *Syncarpha:* when they surround the calyx, and are combined with it, they seem to make part of the flower, as is seen in *Scolymus angiospermus:* but when the two phenomena take place at once, the whole head of flowers does not make more than a single body, apparently hollowed out into seminiferous holes, and its structure can only be unravelled by very delicate analogy; we see this in *Gundelia* and *Opercularia.*

When the pieces of the involucrum are large and sheathing at the base, the name of Spathe is given to it, and the pieces of which it is composed are improperly called Valves. This organization is only met with in Monocotyledons; and when it is mentioned in Dicotyledons, it is as if one said that an involucrum had the form or appearance of a spathe. In true spathes there are sometimes one, sometimes two valves; but in the latter case they are never opposite, but alternate; and the lower one, which is the larger, embraces by its base the upper one. This organization is met

with in all the compound inflorescences of Monocotyledons. The little bracts situated at the base of the pedicels which spring from the spathes, bear the name of SPATHELLÆ.

Among Spathes, we distinguish by the name of GLUMES those which are of a more scaly and dry texture; they are peculiar to the immense family of the Gramineæ. In this sense, the glumes which grow at the base of the locustæ of grasses are analogous to spathes, or involucra; those which are found around each flower, and which are called GLUMELLÆ, are, according to some, analogous to involucella or spathellæ, and according to others, to the true integuments of the flower. The opinion of the former is founded—1st, Upon the analogy with the Cyperaceæ, where the scale is evidently a bract;—2d, Upon the fact that the outer glumella is always situated a little below the inner one; whence it results that these valves are not verticillate, as the true floral integuments, but alternate, as the leaves of the Gramineæ. These reasons appear to me to be strongly in favour of this opinion.

Lestiboudois has been willing to corroborate this theory by a third argument, viz. the quaternary number, which he admits without mentioning his reasons, in the glumellæ; but it appears evident to me, with Mr. Robt. Brown, that the glumes and glumellæ present the ternary number peculiar to Monocotyledons, the outer one being a single piece, the inner one two united.

We sometimes find in the Aroideæ and Palms, very large spathes composed of a single sheathing leaf; an organization possible in Monocotyledons, where the leaves are essentially alternate, but which cannot take place in the involucra of Dicotyledons, the pieces of which are essentially opposite or verticillate.

Bracts approach more or less the sepals, or pieces of the calyx, either when they are coloured or when they are verticillate ; and the transition of the organs of vegetation to those of the flower is found to be so gradual, that the more it is studied the more we see this unity of composition, which forms the base of philosophical Organography. This observation will become more clear from the examination of the structure of the flower itself, which will be the object of the following chapter.

CHAPTER II.

OF THE STRUCTURE OF THE FLOWERS OF PHANEROGAMOUS PLANTS.

SECTION I.

General Observations.

THE flower, considered physiologically, is the apparatus of organs which perform the sexual fecundation, and of those which serve as their immediate envelopes. Considered with regard to Organography, we shall see that it is an assemblage of several (usually four) verticils of leaves, variously transformed, and situated, in the form of a bud, at the extremity of a branch called the pedicel.

The organs which perform the fecundation, are,—the female organs, or PISTILS, which enclose the ovules; the male organs, or STAMENS, which fecundate the others.

The immediate envelopes are the COROLLA, which is of an analogous nature to the genital organs; and the CALYX, which serves as the external covering, and is of a foliaceous nature. To these four organs must be added, for the sake of clearness, the TORUS, which serves as the common base of the corolla and stamens; and the AXIS, which is the prolongation of the pedicel. These six parts spring from the top of the pedicel, and constitute all the essential organs of the flower. All that is found outside the calyx, belongs to the bracts or involucra, which I have already mentioned; and that which is met with in the interior, and does not form part of these six organs, is reduced to some nectariferous glands which do not appear essential to the flowering.

We shall first describe each of these parts in its most simple and least complicated state, joining only to their description the cohesions* which they contract. We shall examine the modifications which they present, in their adhesions, abortions, or affinities with neighbouring organs; and we shall conclude with some observations upon the whole structure of flowers.

SECTION II.

Of the Calyx or Sepals.

The CALYX is the external envelope, usually foliaceous, which is observed in almost all complete dicotyledonous flowers, and which forms the sole envelope

* From analogy with medical language, I call COHESIONS the unions of organs of the same nature, and ADHESIONS those of different organs: thus the sepals united together are COHERENT; united to the ovarium, ADHERENT.

in most of those which are incomplete. It is formed of pieces which are disposed in verticils in one or two rows, and which bear the name of SEPALS, (*sepala*.)

The sepals are evidently organs very analogous to the nature of leaves; and it might be said with some reason, that they are bracts which constantly exist, and form an integrant part of the flower. The identity of nature of the sepals, bracts and leaves, is derived from the following facts:—1st. Their internal anatomy presents vessels and tracheæ as in leaves, and their tissue presents most frequently a great analogy in the distribution of the fibres. 2d. Their surface, as that of leaves, presents stomata, most frequently distributed in the same manner in the same plants. 3d. When they have glands or hairs, these organs are similar in their nature, form, or position, to those of leaves. 4th. They are almost always green, as leaves, and endowed, as they are, with the faculty, both of becoming etiolated in darkness, of decomposing carbonic acid gas, and of exhaling oxygen when placed in water under the sun. 5th. Lastly, they take, under several accidental circumstances, an extraordinary development, and then they absolutely resemble true leaves, as is frequently seen in Roses, for example, (Pl. 17.) We may regard the sepals, then, as being of a foliaceous nature; and it may be said that they are kinds of floral leaves, which by their position take particular forms, and serve as the outer covering of the flower. They are, as leaves, sometimes articulated at their base, and then they become detached and fall off spontaneously, either at the commencement of the flowering, as in the Poppy, or at the conclusion of it, as in *Ranunculus;* sometimes they are continuous, or adherent at their base, and then they do not drop off, and are said to be PERSISTENT. But then they either dry up after flowering, and are termed MAR-

CESCENT, as in the Broom; or they become fleshy, as in certain Ficoids; or they increase in size, remaining foliaceous, and are said to be ACCRESCENT, as in the Alkekengi. Some calyces present a singular mode of fall; viz., their upper parts remain close or united together after flowering, and the tube is cut transversely by a rupture, either near the base or at the origin of the lobes: it is thus that the cap-like calyx of *Eucalyptus* is formed, and in an analogous manner, that of *Scutellaria galericulata* is cut transversely near the base, when the seeds are ripe.

When the sepals are articulated at their base, they can never be united together, and are therefore constantly distinct. When, on the contrary, they are continuous with the stem, they are presented under two states; sometimes free with regard to each other, sometimes united together at their margins by a kind of natural union, taking place before they are visible externally. In this case, we easily recognise, in the greater number of species, the existence of partial sepals, either by the disposition of the nerves, or because the union is hardly ever so complete as for one part not to remain free near the top, forming the lobes of calyces with united sepals.

Calyces with free sepals are said to be POLYSEPALOUS; and when we wish to express at the same time their number as well as freedom, we say BI-, TRI-, TETRA- &c. SEPALOUS.

Those with united sepals are called GAMOSEPALOUS, or improperly MONOSEPALOUS, because, on account of their union, they seem to form only a single body. If they are only united at their base, their free parts are designated by the name of PARTITIONS, and the calyx itself is said to be BI-, TRI-, QUADRI-PARTITE: if the union proceeds as far as the middle, they are named

DIVISIONS, and the calyx is said to be BI-, TRI-, QUADRIFID: if the union proceeds nearly to the apex, the free parts are called TEETH, and the calyx is said to be TWO-, THREE-, FOUR- &c. TOOTHED: if the union reaches the apex, the calyx is said to be ENTIRE: if the sepals are unequally united together, there may result, among other combinations, the following:—Two or three may be united on one side; and there remains on the other, either a single sepal not united so far, or two or three united together beyond the point which connects them with the preceding: the name of LIPS is given to these kinds of parcels, and the calyx is said to be TWO-LIPPED when there are, as is most frequently the case, two sepals united into an upper lip, and three in a lower one: we say of a calyx that it is ONE-LIPPED, when all the sepals are united together and thrown on one side, because the union on the other only takes place in a very incomplete manner. Lastly, there are some rare cases where the sepals are so united by their apices, that they cannot be separated, and the calyx can only open by a rupture at its base; it is this which takes place in *Eucalyptus*, where it is broken transversely near the base of the limb, and is detached in the form of a hood. For a long time the calyx was considered to be a single organ, which was cut or divided, without any reason being given for these pretended divisions; its structure was then almost unintelligible, and unfortunately it was at this period that the terms were established by which its modifications are designated. I do not propose to change them, for the fear of causing too great a confusion; but it is necessary to know, once for all, that all that has been said of the divisions of calyces must be understood to relate to sepals differently united together.

The use of the calyx is evidently to serve for the covering and protection of the other floral organs during

flowering, and sometimes to the young fruit, where it is persistent. It is probable, seeing the foliaceous nature of this organ, that it serves also to elaborate the juices destined either for the flower or the young fruit.

Section III.

Of the Corolla or Petals.

The Corolla is the more or less coloured inner envelope, which is observed in the greatest number of the flowers of Dicotyledonous plants, but which is entirely absent in several others. It is formed of pieces disposed in one or several verticillate rows, and which bear the name of Petals *(petala)*.

The petals differ more in nature from leaves than the calyx does, and very much resemble, as we shall see, the stamens: they usually have neither stomata nor tracheæ; they are of all kinds of colour, except green; and even when they are greenish, they do not appear to owe it to a cause analogous to that of leaves, for they are not capable of being etiolated. They do not disengage oxygen when exposed to the sun, but, on the contrary, they have a tendency to diminish the free oxygen of the air by forming carbonic acid: they frequently exhale very different odours from those of leaves; and these odours, when they are concentrated, act in a peculiar manner upon the nervous system of the human species. Lastly, when they bear glands or hairs, these organs are very different from those of foliaceous parts. All these different characters of the petals are found in the stamens and torus, and hereafter I shall endeavour to prove the identity of the nature of these organs.

The petals are almost always articulated with the torus, and consequently DECIDUOUS: frequently they fall off very early, that is to say, before fecundation; they are then said to be CADUCOUS: sometimes they are continuous or adherent, and then they are termed PERSISTENT—for example, in *Campanula*.

When they are completely distinct from each other down to the base, the corolla is said to be POLYPETALOUS, or, if it is wished to express the number of petals, DI-, TRI-, TETRA-PETALOUS. When they are more or less united together, it is most frequently said, but in an improper manner, that the corolla is MONOPETALOUS, a term for which I substitute that of GAMOPETALOUS, which signifies that the petals are united. This union is seen to be the case, by the distribution of the vessels in the greatest number of cases; it is perceived also more clearly in some plants, such as *Rhodora Canadensis*, *Campanula medium*, or *Phlox amœna*, (Pl. 18, figs. 8, 9, 10, 11) in which we frequently find every degree of union which can possibly be met with, whether in the flowers of the same individual, or in the petals of the same flower. It happens in the Compositæ, that the five petals united into a tube, present in certain flowers a lateral fissure, so deep that the corolla, instead of appearing tubular, becomes strap-shaped. This phenomenon is constant in the Chicoraceæ, where some ingenious philosophers attribute it to the presence of glands which unite the lobes together at the apex: in the other Compositæ it only takes place in the marginal flowers of the capitula, but here also we recognise the original nature of ligulate flowers, in their sometimes happening to retain their tubular form. Thus, I have observed in gardens an accidental monstrosity of *Tagetes erecta*, where the semi-florets were changed into tubular ones, larger than those of the disc.

The degree of coherence of the petals, is expressed by the same terms as those which refer to the calyx; thus we say of a corolla, that it is PARTITE when the petals are united at their base; DIVIDED, when united as far as the middle; DENTATED, when the union proceeds very nearly to the apex; ENTIRE, when the union is complete.

The petals, more frequently than the sepals, present natural cohesions in their upper parts, remaining free at the base; this is seen in the two petals united at the summit, which form the keel of the Papilionaceæ, or still more in the union of the five petals in the common Vine, which takes place at their summits whilst their bases are distinct. They are also sometimes united by their base and apex, the middle parts remaining free, as in some kinds of *Phyteuma*.

The petals arise, in the greatest number of cases, in a single row, equal in number to the sepals, and situated between each of them: when they are in two rows, the external one is between the sepals, and the inner one, which alternates with the first, has its petals opposite the sepals: when the number of rows is more than two, the third has its petals opposite those of the first, the fourth opposite those of the second, &c. Among the exceptions to these laws, we must mention the few cases where the petals are opposite the sepals, as in the Berberideæ.

Each petal, considered with regard to its structure, sometimes presents, as leaves, a kind of support formed by the union into a narrow process of all the bundles which afterwards spread out to form the limb of the petal; this kind of petiole bears the name of the CLAW, *(unguis,)* and the dilated portion that of the LAMINA or LIMB. There is a less number of unguiculate petals than of petiolate leaves. The partial bundles of vessels

which spring from the top of the claw, and spread out into the limb, are in general less distinct, thick, and regular, than the nerves of leaves; the same terms of Penninerved, Palminerved, &c. may be applied to them, but there is seldom any necessity for describing them. The corollas of the Compositæ present a disposition of the nerves which is peculiar to them; viz. each petal, instead of having as usual a middle nerve, is furnished with a very perceptible one upon its two margins, as far as the apex; whence it results, that in the tube of the corolla, where the petals are united, we see five large nerves, each of which proceeds from one of the sinuses, and is formed by the union of the two marginal ones.

When the petals are free and furnished with claws, as in the Pink, these claws are usually straight and near together, thus forming a kind of tube with five slits. If, on the contrary, they are united, as in the Tobacco, their union forms a true entire Tube; and the limbs of these petals united by their claws, may be either entirely free, or united half-way, or as far as the apex.

The entrance of the tube bears the name of the Throat *(faux)*: we may here frequently remark little petaloid appendages, which have received the name of Scales or Appendages when they are free, and which are called the Crown when they are united together, or when it is wished to designate them collectively.

The use of the corolla is evidently to serve for the protection of the sexual organs, especially before their complete developement. Its fugacity, and its nature, so distant from a foliaceous one, do not permit us to assign it any use with regard to the nutrition.

Section IV.

Of the Stamens.

The Stamens, *(stamina,)* or the male organs of plants, arise from the torus, and are placed in one or several rows or verticils between the petals and pistil. Rœper has proposed to give them collectively the name of Andrœceum, in order to have a collective term analogous to those of corolla as concerns the petals, and calyx relative to the sepals, and pistil to the carpels.

The number of stamens is very variable in the different genera—from two to a hundred: when but one is found, it results only from the abortion of the other or others which form with it the regular verticil.

When they are disposed upon only one row, their number is usually equal to that of the petals or sepals; and they arise either opposite the sepals and between the petals, or, what is more seldom, between the former and opposite the latter. We sometimes find several stamens which arise in one row before each sepal; then the total number is the product of the number of sepals, multiplied by that of the stamens placed before each of them.

When they are disposed in two circular rows, there is almost always one opposite each petal, and one before each sepal; and the total number is double that of each of these organs. Sometimes, when the petals are absent, the stamens are found situated alternately opposite and between each sepal: if there be more than two rows, the third is situated opposite the first, the fourth opposite the second, so that the whole number of a regular flower is the product of the number of rows multiplied by that of one of the rows, which is usually equal in number to that of the petals or sepals.

In this sense there is never an indefinite number of stamens, to speak truly; but the greater the number is, the more chances are there of accidental abortions or multiplications, and the more it is neglected to count them exactly: it is usually said that the number is indefinite when it exceeds twenty.

Each stamen is composed of a filament and an anther.

The FILAMENT *(filamentum)* is a body which springs from the torus; and its form is sometimes cylindrical, or subulate and very long; sometimes compressed; more rarely expanded towards the apex into a kind of scale or cap, as in *Borago laxiflora.* In texture it is very analogous to petals, especially to their claws. It is coloured as they are; bears the same kinds of hairs and glands; is devoid of stomata and tracheæ, &c. Their length seems only to be determined by the necessity of supporting the anther at a sufficient height for it to be placed in a favourable position with regard to the stigma. Thus, in the greatest number of cases, the filament is of the necessary length for the anther to be nearly of the height of the stigma, or a little above it; but frequently in drooping flowers, the filament is shorter, and the anther is found above the stigma. This law is often modified by the torsion or peculiar movements of certain flowers. The filament, as it only serves for the support of the anther, may be, then, either very long or very short; in this last case, it is sometimes so short that it is said to be completely wanting. When it is articulated at its base with the torus, the stamen detaches itself and falls off after fecundation; when it is not articulated, as in *Campanula,* it perishes and dries up without falling.

The ANTHER (*anthera*) is a kind of purse borne by the filament, containing a powder which is called the POLLEN. As the pollen itself contains the fecundating matter, and is consequently the essential part of the

organ, the anther which protects and nourishes it is also a very important one. It is situated upon the top of the filament in three different ways:—1st, It is frequently attached by the middle of the back to the very tapering extremity of the filament; and then, as it is placed in a vertical position before the flowering, and afterwards takes an horizontal one, it is said to be VERSATILE. 2d, In several cases it is attached by its base to the apex of the filament of which it appears to be the continuation, it is then ERECT. 3d, In some families it is adherent to the filament by its whole dorsal face, so as to have no movement; it is then said to be ADNATE or ADHERENT to the filament. In this last case, it frequently happens that the top of the filament is prolonged beyond the anther into an appendage, either strap-shaped or in a filiform point, as in the *Oleander*, or as a gland, as in *Adenanthera*. Sometimes it is the connectivum which is prolonged in the same manner, sometimes the cells themselves; so that the terminal appendages result from very different anatomical causes.

Anthers are generally composed of two membranous sacs, applied to one another and joined by a body which is called the CONNECTIVUM. This body is sometimes so small, and scarcely apparent, that it is neglected in descriptions; sometimes so large and well developed, that the two cells of the anther are separated from each other, as is seen in the Sages.

We find a certain number of anthers which have but one cell: sometimes this conformation appears natural to the plant, and then it is only met with in those anthers which are attached by their base to the top of the filament; sometimes it results from an accidental abortion of one of the cells, which especially takes place when the connectivum is very large and the cells very distant, as in the Sage; sometimes it is owing to the filament

being, as it were, split into two, or divided, so that in the place of one stamen with a bilocular anther are found two with unilocular ones: this is observed in one of the stamens of *Impatiens noli-tangere*.

I do not know that any anthers exist which have naturally more than two cells, but this appearance results in several cases from two causes:—1st, Each cell is most frequently divided into two small ones by a longitudinal fold of the dorsal part, and this frequently gives the anther the appearance of being four-celled: 2dly, It sometimes happens that two or more neighbouring anthers are united together, so that the apparently simple body which results, appears to be four-, six-, or many-celled; for example, in the *Salix* improperly called *Monandra*, and probably in the Yew. We shall revert to this subject on speaking of the Cohesion of the Stamens.

The cells open at maturity in four different ways:—

1st. The most frequent case is that where the opening takes place by a longitudinal fissure through the middle of each cell; and when the anthers are two-celled, we say that they are BIRIMOSE.

2d. It happens more rarely that the opening takes place by transverse fissures, as in the Lavender.

3d. Several anthers open at their apex by two pores (BIPOROSE) situated at the top of the two cells—in *Solanum*, for example; or by one pore at the top of a unilocular one, as in *Amaranthus*. This kind of dehiscence may result from the longitudinal fissure remaining united except at the apex.

4th. The most singular case is that where the cells open by valves which detach themselves from the base upwards, as is seen in the Barberry and Laurel, and in the two families to which these plants belong—the Berberidæ and Laurineæ.

The position of the anthers with regard to the pistil ought also to be observed. The most frequent and natural case is that where the anther, whatever be its mode of attachment, has its back towards the outer, and its cells on the inner side of the flower: it is this that is meant whenever it is not expressed to the contrary in descriptions; when it is necessary to express it, we say that it is INTRORSE (*introrsa, antica*). In some plants it is placed in the contrary way, so that its back faces the pistil, and the cells open towards the calyx; this kind of anther is called EXTRORSE (*extrorsa, postica*): we observe it very clearly in certain adnate anthers, such as those of the Magnoliaceæ, or in those with flat filaments, as in *Iris;* but when the filaments are slender, or when the anthers are erect or versatile, the observation of their true direction presents some difficulties, because it often happens that the filament is so twisted as to place the anther in a situation different from its natural one; thus we may often mistake their true position in the Ranunculaceæ.

The form of each of the cells is sometimes round, and then we say of the anther that it is DIDYMOUS: more frequently oval; sometimes long or linear; this last case especially takes place in adnate anthers, as those of the Magnoliaceæ: when these cells are erect, they present two convex bands, separated by a rectilinear furrow: sometimes they are at the same time adnate, linear, and more or less curved, and then they present inequalities and curves of a remarkable appearance; we see this in the Gourd, in *Durio, Eriodendron,* &c.; these anthers are called ANFRACTUOSE. Those with round cells frequently open by a transverse fissure, those of a linear form by a longitudinal one, and oval anthers present all kinds of dehiscence.

The colour of the anther is often yellow; sometimes

orange, brick-coloured, violet, purple, or white; never green or a true blue. But we must take care not to confound the colour of the anther with that of the pollen; and it must be remarked that the colour of the former differs before, during, and after fecundation.

The Pollen is a mass of granules contained in the anther, and coming out of it at its dehiscence. According to Guillemin, who has recently studied this important organ with care, these grains, considered before their exit, appear disposed in a regular series, following the direction of the walls, and floating in a viscid fluid: at whatever age they have been examined, they have hitherto been found completely free; and, if it be really so, we may suppose that their nutrition takes place by the simple absorption of the surrounding fluid by their walls; but it may be believed, with some likelihood, that in their first stage they adhere to the walls of the anther by a filament, which escapes our sight on account of its fugacity or shortness, but which is sufficient to keep them in continuity with the rest of the tissue; Turpin goes so far as to designate the part projecting into the interior of each cell as being that which bears the pollen, and proposes to call it by the name of Tropho-pollen. The adherence of the grains of pollen with the anther, in their earliest state, seems to me probable—1st, on account of the general analogy of all the organs of plants;—2dly, on account of the special analogy of the grains of pollen with the ovules; an analogy which is so great, that, as we shall afterwards see, one half of the anther is sometimes found bearing pollen, and the other half ovules.

The grains of pollen at their maturity are sometimes completely free, which is most frequently the case; sometimes kept in a kind of network formed of fine filaments, as in the Onagrariæ: and sometimes united

in compact masses, as in the Orchideæ and Asclepiadeæ.

The surface of the grains presents an important difference: sometimes it is perfectly smooth and not viscid, as in *Justicia quadrifida* and a multitude of other plants: sometimes it is invested with a viscid layer differently coloured, and which appears to be produced by true secreting organs; we see this in most of the Cinarocephalæ, Heliantheæ, &c.: the surface of some bears mamilliform eminences, as in *Cobæa:* in the Cucurbitaceæ it is furnished with pointed projections, which Amici considered as kinds of lids terminating in a point.

The general form of the grains of pollen is most frequently globular, oval, or elliptical in Dicotyledons, and lengthened elliptical in Monocotyledons. It is frequently remarked, that the oval or elliptical ones are marked on one side with a longitudinal furrow, resembling that in a grain of wheat. They are frequently found polyhedral, as in the Chicoraceæ; some are nearly triangular, as those of the Proteaceæ and Onagrariæ; those of *Colutea* are oval and truncated at the extremities. Among elliptical or elongated pollens there are sometimes found curved ones: Grew has even mentioned ramified ones, but this observation does not appear to have been verified. In general, plants of the same family have their pollen nearly alike; but analogous forms are found in very different families.

Each grain of pollen contains a fluid which appears to be slightly viscid, and has been named the Fovilla; it is the true fecundating liquor of plants, and is full of little grains, endowed with a peculiar motion, and which are called Granules.

The pollen grains open at maturity either by a regular dehiscence, or, most usually, by an irregular

rupture: this opening is particularly caused by the application of water, which is sometimes absorbed by them; and the diluted fovilla appears to come out in an insensible manner. It is generally thought that the grains, falling on the stigma, which is almost always viscid and humid at the period of fecundation, then open and deposit the fovilla; this appears to be absorbed by the stigma, and, reaching the ovules, excites the young embryo and conveys to it the vital movement. Others think that the granules penetrate into the ovules and there form the embryo. But in a subject so delicate, it is difficult to form a decided opinion: I shall only observe, that the constant presence of animalculæ in the fecundating liquor of animals, and of granules in that of plants, is not sufficient to destroy the opinion of the pre-existence of germs in the ovules; and we might believe, with some likelihood, that the animalculæ and granules are the exciting agents of a germ pre-existing in the ovule. This question, more physiological than anatomical, would be out of place here; and I hasten now to resume the description of the male organs of plants.

The stamens may be coherent or united together in three different manners; viz. by the filaments, by the anthers, or by both organs at the same time.

When the cohesion takes place by the filaments, it is usual to say that the filaments are MONODELPHOUS when all are united together; DIADELPHOUS, when they form two parcels; POLYADELPHOUS, when there are several; but these terms fall far short of giving a complete idea of the variety of the real cases.

The cohesion of the filaments together is so much the more easy, as they are naturally of a more spreading form, or nearer one another in their primitive position: it may take place in every degree, as in the petals;

thus, there are some stamens whose filaments only cohere at the base—for example, several Pinks; others where they do so as far as the middle, as the two stamens of *Salix incana;* others, where the union proceeds very nearly to the top, as in most Meliaceæ, some Malvaceæ, &c. We also find some free at their bases at the time of flowering, and united at the top, as in *Lobelia.* In this respect we find as many differences among stamens cohering together, as in petals united into a gamopetalous corolla.

The cohesion of the filaments may take place in a uniform manner among all the stamens, whether they be in a single row, as in most Amaranthaceæ and Meliaceæ, or in several united by their bases, as in Malvaceæ.

Sometimes the stamens are distributed regularly in parcels united at the base, and equal in number to the petals or carpels; thus, in *Hypericum* and *Melaleuca* there are five parcels alternate with the petals, and each composed of a nearly definite number of stamens. Sometimes, the stamens being almost in a single row, and double the number of the petals, as in the Papilionaceæ, their filaments are all united, either all together, in a cylindrical sheath, as in *Cytisus*—or nine together, in a split sheath, on the upper side, and the tenth remaining free, as in *Colutea*—or five on one side and five on the other, forming two semi-sheaths, as in *Æschinomene*—or in two lateral parcels, and a single one free, as in several kinds of *Dalbergia.* Of other cohesions, the most singular are observed in some other families: thus, in several Cruciferæ, such as *Œthionema* and *Sterigma,* of the six stamens, the two lateral are always free, and the four others united by the filaments, either partially or wholly. It must be remarked, that in the genera which present this disposition, when these filaments

remain free they have a tooth projecting from the side where they have a tendency to unite with the neighbouring one. In the Gourd, of the five filaments, one is most frequently free, at least at the base, and the others intimately united in pairs. In the *Fumaria* and the other genera of the same family, we find two parcels, each bearing three anthers, of which the middle one has two cells, and the two lateral one cell; whence it might be presumed that the real number of filaments is four, united two and two.

When the stamens are united by their anthers, they bear the name of SYNANTHEROUS, or SYNGENESIOUS. This phenomenon, although less varied than the preceding, presents also some differences; in general it takes place in all the anthers of the flower at the same time, and their cohesion then forms a kind of ring through which the style passes. In this case, the anthers thus united are introse, opening by longitudinal fissures; and the stigma, elongating in the interior of the ring, receives the pollen of the anthers. This is observed in the immense family of the Compositæ and Lobeliaceæ. Sometimes the two cells of the anther, being separated by the bifurcation of the filament, or an elongation of the connectivum, each unites with the cell of the neighbouring stamen, and thus form bilocular parcels which might be taken for true anthers: this singular conformation is presented in *Stapelia*, and perhaps in the bilocular anther of the Fumariaceæ.

Finally, the third combination is that of the stamens cohering both by their filaments and anthers. As yet but a very small number of examples is known. *Barnadesia*, a genus of the Compositæ, has the filaments united into a complete tube, and the anthers form a ring with the cells opening internally: the Symphonieæ (a tribe or family between the Guttiferæ and Meliaceæ)

have the filaments united into a tube, and the anthers open by longitudinal fissures on the outside of it, a phenomenon slightly resembling the structure of the Cucurbitaceæ. *Salix monandra* presents two stamens united by the filaments and anthers. *Morina persica* has four fertile stamens, joined two and two, in the same way. Lastly, the Yew appears to have eight to ten stamens united by the filaments and anthers, forming a bundle which expands at the top, and bears the anthers on its inner side; this form of the filament some authors have named ANDROPHORE.

The stamens, as I have said above, always arise from the torus very near from where the petals spring; they easily contract adhesions with these organs; but these adhesions are very frequent when the petals themselves adhere together, and very rare when they are free. Thus, in all gamopetalous corollas, the filaments are united to them, except in the Campanulaceæ, and in polypetalous ones the stamens do not adhere to the petals except in the Malvaceæ, Caryophylleæ, &c. and then but slightly.

As the function of the stamens is connected with their being the male organs, it will be explained in detail in the Physiology; it is sufficient here to state that this opinion, almost unanimously admitted, is founded,—1st, upon the examination of their structure; 2d, upon the fact that when flowers are deprived of them either naturally, as in diœcious plants, or artificially, as in those mutilated by insects, &c., they are constantly sterile; 3d, upon the mules or hybrids which are produced when the pollen of one plant is applied to the stigma of another.

Section V.

Of the Pistil or Carpels.

The pistil, taken collectively, is evidently the female organ of the flower, since we see it after flowering changed into fruit and containing the seeds. It has for a long time been considered as a single organ; but its structure, and especially that of the fruit which succeeds it, only becomes intelligible when it is considered in the same manner as all the other organs of the flower, that is to say, as composed of elementary organs, sometimes free, at others cohering together, and which I call Carpels.

The Carpels spring from the centre of the flower, and are arranged in different manners, of which the following are the principal, viz.:—

1st. They are verticillate around a real axis, which is the prolongation of the pedicel, and are adherent to it by their inner angle; this takes place in the Malvaceæ, where we see five or more carpels around a column which arises from the pedicel. This column is expanded (in *Stegia*, for example) into a kind of terminal disc, and the carpels adhere to it by their inner angles. We observe an analogous organization in the Euphorbiaceæ; it is also met with in certain foreign genera, such as *Gyrostemon*, which seem intermediate between these two families, otherwise so different.

2d. We also find the carpels verticillate at the top of a central column, but pendulous from it, and consequently only adherent by the summit of their inner angle. We see this in the Geraniaceæ: the carpels do not adhere to the column by their edges, but hang from its apex by a long pedicel.

3d. The carpels may also be verticillate at the apex of the axis, but erect and adherent by the base of their inner

angle; this axis is sometimes so short that it is considered absent, as in all the Crassulaceæ, *Aconitum, Aquilegia, Illicium,* &c. The place of the column is then vacant in the centre of the verticil formed by the carpels. Sometimes the axis is slightly prolonged, and the verticil of carpels is, as it were, elevated, as takes place in several Rutaceæ.

4th. The carpels may be disposed in a spike around the central column, as is seen very clearly in the Tulip-Tree, *Magnolia,* several of the Ranunculaceæ, *Myosurus,* &c. These carpels sometimes present at their base little scales, which may be considered as true carpellary bracts: I have observed them in some Ranunculaceæ. The nature of these organs deserves the attention of Naturalists.

5th, If the column be very short or round instead of being elongated, the carpels, instead of being in a spike as in the preceding case, may be agglomerated into a head more or less compact around this column, as is seen in the Bramble, the Strawberry (where the column is fleshy), the *Anona,* most kinds of *Ranunculus, Alisma,* &c.

6th. The carpels may be dispersed upon the walls of the torus adherent to the calyx, as is seen in *Rosa,* the only example perhaps of this conformation in the whole vegetable kingdom.

All the preceding dispositions suppose a plurality of carpels, and this is in fact, in my opinion, the natural and normal state of flowers; but by abortions and cohesions all may be reduced to a single one, either in reality or in appearance.

Each carpel may be considered as a little leaf folded upon itself, and containing the germs which are developed after fecundation. These germs bear the name of OVULES, and the carpels which contain them the OVARY.

The carpels are usually sessile, sometimes furnished at the base with a small support independently of the central column, and which represents the petiole of the leaf; this little support receives the name of THECAPHORE. It is visible in several species of *Sterculia,* in a great number of Leguminosæ, Capparideæ, (especially in *Cleome longipes,* where it is nearly a foot long,) &c.

The ovules are almost always attached to the margin of the little leaf which, by folding, forms the ovary, or, which is to say the same thing, on both sides of the inner angle of the carpel; the portion, usually slightly thickened, where they adhere, bears the name of PLACENTA; the apex of which and of the carpel is prolonged into a filament, sometimes very long, at others very short, called the STYLE, and this bears a glandulous organ, glutinous at the period of fecundation, which receives the pollen, makes it burst, and then imbibes the fovilla: it is a kind of pistillary spongiole, and is called the STIGMA. Let us rapidly review these different points, which we shall be obliged to revert to more in detail on speaking of the fruit.

The analogy of the carpel to the leaves is deduced from the following facts:—1st. It is frequently of the same texture and colour, and has the same faculty of decomposing carbonic acid gas when exposed to the light. 2d. It frequently bears stomata, and when it has hairs or glands, these organs are often analogous to those of leaves. 3d. It very frequently presents nerves very analogous in their distribution to those of leaves. 4th. The ovules are situated in most carpels in the same places which correspond to the germs, which in some leaves, as in *Bryophyllum,* are developed without fecundation. 5th. We not unfrequently see the carpels, by degeneration, develop into true leaves, as I have observed it in *Lathyrus latifolius.* We also very easily

see this analogy in certain monstrosities of Cherries, which, instead of having but one carpel, bear several, sometimes in the state of ordinary ones, at others in the state of leaves folded upon themselves.

The ovary being formed by the folding of a leaf, presents in different cases forms connected with its origin. Thus when it is free from all pressure or cohesion with the neighbouring ones, it is either compressed and flattened, when the two halves of the leaves are even and applied to one another, as in the Pea; or swollen out, but with a dorsal nerve, when the leaf has a middle nerve and its sides are curved upon one another, as in the French-Bean and Bladder-Senna; they are nearly in the form of a horn when the leaf has no middle nerve, as in *Colchicum.* It sometimes happens that the margins of the leaf are folded back upon themselves in the interior, and form two-celled carpels, as in *Astragalus.* When the carpels are verticillate and close to one another, they then take, in consequence of their pressure, a triangular form, the two lateral parts being flat and inclined inwards, and the dorsal surface being flat or convex, or even angular; this is seen in the Crassulaceæ. This is still more evident when they are united together by their lateral faces.

The style arises from the carpel originally near the apex, but sometimes from the middle or base of the inner margin, as is seen in *Alchemilla;* the point whence it proceeds is always that where the placenta terminates; its length is determined by the proportion which ought to exist between the position of the stigma and that of the anthers; when it is absent the stigma is sessile upon the summit of the ovary. The form of the style is usually slender, cylindrical, and simple. But as the ovules are generally disposed upon two rows, or placentæ, each of them has its stylary prolongation, and that of

each carpel may be considered as formed of two partial styles, sometimes perfectly free, at others more or less united together; and then we say that it is bifid, and that it has two stigmata. The Euphorbiaceæ show very well these different states of the carpellary styles, both simple and forked.

When the styles are detached or raised above the carpels, they are most frequently free; at times united with the central column, as in *Geranium*.

The stigma is, as we have said, a kind of spongiole supported by the pistil. It is usually situated at the extremity of the carpellary styles, and we say that there is but one when they are united the whole way, and that there are two when they are only united part of their length. This manner of expression has often caused the branches of the style to be confounded with the stigmata, which in reality are only the glandular part, whatever place it occupies. Thus, for example, in several Leguminosæ this portion is naturally near the extremity; in the Iris the branches of the style are flat, petaloid, and two-lipped, the upper very long and often bifid, the lower very short; it is in the transverse fissure which results from the position of these two lips that the glandular part or true stigma is found.

The stigma, whatever be its position and form, is beset with viscid papillæ. The pollen, when it falls upon it, experiences the action of this humidity—it bursts; the fovilla is absorbed by the spongioles, and on applying coloured fluids to them, as Bulliard did, we see that they follow the vessels in the interior of the style, penetrate into the placenta, and thus reach the ovules. It is by this means that vegetable fecundation is performed. The collection of vessels which go from the stigmata to the seeds bears the name of the PISTILLARY CORD; we shall revert to it on speaking of the fruit.

The style bears, moreover, in some plants, hairs which have been called Collecting Hairs *(pili collectores);* they are found in the Compositæ, and they serve to excite the anthers, cause their dehiscence, and attract the pollen to the stigmata. The Campanulaceæ also present collective hairs, which in position and structure appear very similar to those of the Compositæ; but it is not impossible that their function is slightly different. In fact, the part of the pistil of the Campanulas which we call from analogy by the name of stigma, appears completely inaccessible to the pollen at the period of flowering, and Cassini supposes that the hairs perform perhaps the function of stigmata; this subject deserves to be studied with care.

The carpels have a greater tendency to unite together than the more external organs, which is connected, doubtless, with their nearer approach to one another, caused as well by their position as by the pressure of the outer organs. We ought then to study carefully the new appearances which result from these cohesions. This union may take place by the ovaries alone; by the ovaries and styles; by the ovaries, styles, and stigmata; by the styles and stigmata, the ovaries remaining free; and, lastly, by the stigmata alone.

When two or more carpels are joined together by the ovaries, there results an ovary composed of several partial ones, which produce as many cells as there are carpels; this union takes place generally only in verticillate carpels, and there results a general ovary with cells verticillate around a real or imaginary axis. These cells are triangular, with the inner angle acute and the external face convex. We shall see, in speaking of the fruit, the internal conformations which result from these unions; I shall only remark, for the present, that every ovary with opposite or verticillate cells, is formed by the union

of the ovaries of several carpels. It is usual in this case to say, very improperly, that the plant is monogynous and polystylous, or with one ovary and several styles; whilst, perhaps, it would be better to say that it is GAMOGASTROUS, or has its ovaries united. The union of the ovaries may take place by the base only, as in *Nigella orientalis;* or half way, as in *Nigella arvensis;* or as far as the apex, which is the case most frequently; the partial ovaries united half way form those which are said to be split or branched.

When, besides the ovaries, the partial styles are also united together, there results from their cohesion a style apparently single, but formed in reality of as many partial ones as there are carpels. It is then said that the flower is MONOSTYLOUS, which would be more correctly expressed by the word GAMOSTYLOUS. In this case the stigmata or the branches which bear them are distinct; they are always equal to, or double the number of that of the cells of the ovary; they are equal in number when the styles which arise from each placenta are united together as far as the apex; double the number when they remain distinct towards the top. Thus the Euphorbiaceæ have indifferently three or six stigmata, when there are three primitive carpels.

Lastly, when the partial stigmata are all united together, there results an apparently simple one, sometimes round, at others more or less divided into angles or protuberances, the number of which is equal to, or double that of the carpels, which are then entirely united.

The cohesion may take place in an inverse manner. Thus, for example, in several Asclepiadeæ the ovaries remain free and distinct, and the partial styles are united into a single body, as in *Asclepias;* sometimes the styles are so short, that the union only takes place in the stigmata, as is seen in *Stapelia.* This kind of organization

can be so little explained in ordinary terms, that no particular name has been given to it, and the flowers where this phenomenon exists are sometimes placed among those with one, and at others among those with two pistils. Several of the phenomena which the parts of the pistil present, will only be intelligible when we examine the structure of fruits.

Section VI.

Of the Torus and the Adhesions which it causes among the parts of Flowers.

The torus, or proper receptacle of flowers, appears to be an expansion of the top of the pedicel, from which arise the petals and stamens, and which may be considered as the base of all the male or corollary parts of flowers. This base of the petals and stamens being formed by the abortions or partial developments of these organs, does not really deserve the name of organ; but we are obliged to describe it by such a name in order to avoid much circumlocution. Turpin, who also admits that it is formed by the bases of abortive stamens, has described it under the name of *Phycosteme*, which it would be very convenient to admit, if that of Torus had not been proposed by Mr. Salisbury some years before.

It is generally (perhaps always) devoid of stomata externally, and tracheæ internally; it is coloured with various tints, white, red, yellow or blue, but scarcely ever green; it does not decompose carbonic acid gas, and does not become green when exposed to the light; it sometimes bears glands and hairs, but these are of a very

different nature from those which are found upon foliaceous organs; it destroys the oxygen of the surrounding air, and transforms it into carbonic acid, furnishing the carbon at the expense of its substance.

This organ performs especially an important function in the structure of flowers on account of its productions and its connexions. Its productions are:—1st. The stamens and petals which we have described above in their ordinary state;—2d. Nectariferous glands, to which we shall presently revert;—3d. Different expansions, which present a great resemblance to the petals or stamens, and which have often been confounded with one or the other of them. Thus, for example, we remark in the Columbine little lanceolate scales, flat and pointed, situated between the stamens and the pistil, and which might be called either abortive stamens or inner petals; these organs arise from the torus, and remain sometimes around the base of the fruit. Organs analogous to these, but of a more petaloid appearance, larger and more numerous, arise between the stamens and carpels of *Eupomatia Laurina*, and are also productions of the torus. We find in *Pæonia Moutan* these same organs united together, and forming a kind of petaloid involucrum around the ovaries, and in the variety of this plant which Andrews has named *papaveracea* they cover the carpels without adhering to them. Mr. Brown has remarked that these appendages sometimes bear anthers, and we are thus authorized in considering them as abortive stamens. If I have mentioned them here as productions of the torus, which is true, it is that their structure will presently serve to enable us to understand the developments of this organ.

The torus, in a very great number of plants, is but little enlarged, and is strictly reduced to the narrow circular space which is found between the calyx and pistil.

It is, then, from this zone, situated below the ovary, that the petals and stamens proceed; we call them HYPOGYNOUS, and the plants which have this organization THALAMIFLORÆ. In this case all the principal organs of the flower,—the calyx, the ovary, and the productions of the torus, are necessarily distinct and not adhering together. But it frequently happens that the torus extends either inwardly upon the pistil or its support, or outwardly upon the calyx, or upon both at once, and it contracts an intimate adhesion either with one or both of these organs. Let us follow the details and the consequences of these adhesions of the torus.

In a great number of the Leguminosæ the torus is prolonged around a very slender pedicel, which supports the ovary, and forms a kind of small sheath, sometimes very short, as in *Peraltea*, sometimes as long as the pedicel, and reaching the base of the ovary in *Neurocarpum ellipticum* and *Martiusia*. In several Capparideæ the torus is prolonged, and intimately surrounds the support of the fruit,—for example, in *Gynandropsis*,—and the stamens arise above this sheath. In the Aurantiaceæ, the torus, which is thick and glandular, is prolonged and intimately applied to the verticillate and membranous carpels of these plants, and increasing with the fruit forms the glandular, yellow, and valveless envelope which incloses the carpels. The same thing occurs in the Poppy, except that the prolongation of the torus is thin, strongly adherent, and does not reach entirely to the top of the carpels, so that at their maturity they open at the apex. It is the same in the fruit of *Nuphar;* and we see that these examples only differ from that of *Pæonia Moutan*, above mentioned, in that the prolongation of the torus does not adhere to the carpels in this Pæony, whilst it does so in the Poppy and *Nuphar*. The torus of *Nymphæa* presents another peculiarity—

the stamens adhere by their base to that portion of the torus which adheres to the ovary, so that they have the appearance of springing from its sides.

In all these examples, which might be easily multiplied, there are evident proofs of this prolongation and adhesion of the torus with the carpels or their support. It is only in plants with a free ovary and numerous stamens that we can expect to meet with any evidence of it.

The second case, which is more frequently met with than the preceding, is where the torus is adherent with the base of the calyx, as it is from this portion of the torus that the stamens and petals arise. These organs seem to spring from the calyx, and the plants in which this organization takes place are, for this reason, called CALYCIFLORÆ; as in this case the base of the stamens is a little above that of the ovary, the name of PERIGYNOUS has therefore been given to them. We may see this in the Salicariæ, most Leguminosæ, Rosaceæ, &c. The portion of the torus united to the calyx presents the appearance of a membrane, either petaloid, indurated, or glandular, and perceptibly differing from that portion of the calyx which is not lined with it.

The immediate consequence of this adhesion of the torus with the calyx is, that the sepals necessarily adhere together at their base, into a gamosepalous calyx. Sometimes this adhesion is extended very far, as in the Salicariæ, and then the petals and stamens arise from near the top of the tube; sometimes it is very slight, and then they proceed from the base; in the last case, which is remarked in the Leguminosæ and Terebinthaceæ, it is sometimes difficult to perceive otherwise than by analogy whether the stamens be hypogynous or perigynous. There are cases where the portion of the torus, united to the calyx, is thickened at the top, and forms a kind of disc, from which the petals and stamens

take their origin; this is seen in several Rhamneæ and Celastrineæ.

It may be remarked in general, that when the torus is not adherent to the calyx, or, in other terms, in hypogynous flowers, the petals of plants of the same family are either constantly free, as in the class Thalamifloræ, or constantly united, as in the Corollifloræ; whilst on the contrary most families of the Calycifloræ present almost indifferently the petals free or cohering, as we see in the Rhamneæ, Leguminosæ, Cucurbitaceæ, Crassulaceæ, Portulaceæ, Caprifoliaceæ, &c.

We have seen what takes place when the torus adheres to the ovary or to the calyx alone; let us examine what happens when it is adherent to both organs at once.

It may be prolonged and united to the two organs, without their being joined together; this is observed, although in a very imperfect manner—1st, In some Leguminosæ, where the torus adheres to the calyx by the side where it bears the stamens, and is prolonged on the other into a little sheath which surrounds the base of the ovary. 2d, In the Capparideæ, where it is prolonged along the base of the ovary, and where it often happens that it adheres also to the base of the calyx, although by a scarcely apparent prolongation. But this organization is especially visible in the Passifloreæ. Here the torus is much developed; it expands and is united on one side to the base of the calyx, which it lines with a petaloid lamina, and then gives origin to one or more rows of coloured filaments, free in *Passiflora*, and more or less cohering in *Murucuja*. Besides this expansion, it is prolonged upon the base of the ovary, which it narrowly surrounds, and it is from this portion that the stamens spring. Thus the Passifloreæ are calycifloróus, inasmuch as their torus adheres to the calyx; but they differ from all the other Calycifloræ, and approach the

Cappaideæ, in their stamens arising from that portion of the torus which does not adhere to the calyx.

Except the small number of examples which I have mentioned, it generally happens that when the torus adheres to the calyx and the ovary, it tends to unite them together throughout the whole extent, where they are found contiguous; we say then that the ovary is ADHERENT to the calyx, or the calyx to the ovary, or simply that these organs are ADHERENT. This union of organs so distant from each other only takes place by their uniting with the intermediate organ. The torus, reduced to an indistinct lamina throughout all the united part, is developed above, at the point where the limb of the calyx becomes free: sometimes it forms an adherent lamina to this limb, which is then prolonged a little into a tube, as is seen in several Rubiaceæ, as *Gardenia;* sometimes it is expanded into a kind of disc, which partly covers the ovaries, and gives origin to the stamens, which are then (hardly correctly) said to be EPIGYNOUS, such are the Umbelliferæ and Rhamneæ; most frequently it is not perceptibly prolonged either along the tube of the calyx, or upon the ovary, and then the petals and stamens arise from the circular line which is found at the point of separation of the ovary and calyx. This position has caused the name of INFERIOR ovary to be given generically to all those which are adherent, because they seem in fact below the petals; or to the corolla that of SUPERIOR, because it seems above the ovary; but the numerous cases where the torus is prolonged upon the calyx, without the latter adhering to the ovary, and where, consequently, the corolla ought to be called inferior, although it is evidently above the ovary, have caused these expressions, founded upon appearances, to be abandoned, and that of ADHERENT ovary or calyx to be employed, which expresses the fact without any ambiguity.

SECTION VII.

Of Abortions of Parts of the Flower, or of their Degenerations.

All the parts of flowers may either disappear more or less completely, or present themselves in unusual forms; and it is of great importance, in order to appreciate the true symmetry of plants, to recognise them under their different appearances; it is this that we are now about to do, very rapidly, examining first the cases where all the similar parts, that is to say, those which compose the same organ, undergo the same change.

The calyx is more rarely absent than any other organ, probably because its external position causes it but seldom to suffer in its development by the pressure of neighbouring organs. In plants where it is free, I only know *Nemopanthes* in which it appears to be entirely absent, or in which it is reduced to a simple, scarcely apparent rim. In those where it is adherent, the tube is united with the torus and ovary, so as to be hardly visible; and the limb or part not united is sometimes absent. Thus, for example, in the Umbelliferæ, when this limb exists, it appears under the form of five little teeth, as in *Œnanthe;* but in a great number of cases it is completely abortive, and is replaced by a small circular rim, analogous to that of *Nemopanthes.*

When the flowers are collected into compact heads, and inclosed in an involucrum, the calyx becoming as it were an internal organ, and being submitted to the pressure of the neighbouring flowers or bracts, presents abortions more frequently. This is but seldom the case in flowers where it is not adherent; but *Diplolæna,* one

of the Rutaceæ, presents an example of it; here the five sepals are reduced to scales, because the flowers are in a compact head. We find more numerous and decided examples in families where the ovary is adherent, and the flowers capitate, such as the Dipsaceæ and Compositæ. In these plants, the tube of the calyx is reduced to a thin membrane adhering to the ovary, and the limb appears under different forms. Sometimes it has five foliaceous teeth, like those of ordinary calyces, as in *Catananche*. These teeth are sometimes changed into membranous scales, free, as in *Centaurea Cupina*, or united together, as in *Hymenopappus* and *Favonium;* or into almost spiny points, as in a species of *Cnicus;* or into bundles of simple hairs, as in *Sonchus;* united together, and thus appearing branched, as in *Stæhelina;* or feathery, as in *Scorzonera*.

It is so certain that the pappus of the Compositæ is the true limb of the calyx, that it sometimes puts on every appearance of it; thus M. Dufresne has shown me a plant of *Podospermum laciniatum*, (Pl. 18, fig. 1, 2,) the pappus of which was replaced by five linear, slightly foliaceous lobes.

I shall revert to these different forms of the pappus when speaking of the fruit, and I shall only remark here, that every organ called Pappus is only the limb of the adherent calyx of plants with capitate flowers, in which this organ is half abortive, or deformed by the pressure of neighbouring flowers; sometimes even it is entirely abortive, and we then say that the pappus is absent: it is replaced by a small circular rim, as in most Umbelliferæ.

The Valerianeæ, although having their flowers distinct and not capitate, present also a true pappus; this results from the limb of the calyx being rolled inwards during flowering, and submitted consequently to a pres-

sure and etiolation as powerful as that which in the Dipsaceæ results from the vicinity of other flowers. The genera where the limb is not rolled inwards have it developed into foliaceous teeth, as in ordinary calyces.

The abortion or complete absence of the sexual organs of plants, or of one of them, is a phenomenon which constantly happens in all plants said to be Unisexual, and accidentally in several others. Thus, to commence with the latter case, which is the clearer, *Lychnis dioica*, although belonging to a family usually hermaphrodite, presents certain individuals where the female organs are well-developed, and then the stamens are reduced to simple rudiments; and others where the stamens are well developed, and where the pistil is abortive, so that in its place is only seen a little protuberance with the rudiments of five stigmata. The same phenomenon takes place in *Spiræa Aruncus* and *Sedum Rhodiola*, &c. All plants which present this phenomenon accidentally are said to be Diœcious by abortion; thus, in several Compositæ, part of the flowers of each head are devoid of ovary, style, and stigma by abortion, and others have no perfect stamens, so that they are Monœcious by abortion. Thus, in *Diospyrus*, *Gleditsia*, &c., a part of the flowers are devoid of pistils, another of stamens; and we find, besides, others where the two organs exist together, constituting that state of flowers which botanists have called Polygamous by abortion.

These three systems of flowers, unisexual by abortion, are frequently met with in almost all the families where we also find hermaphrodite ones; such are the Caryophylleæ, Compositæ, Valerianeæ, Ebenaceæ, Thymelææ, Leguminosæ, &c.; and in all these cases it is evident that the two sexes exist typically, and that one of them is not developed.

When the female organs are not entirely abortive, we find in their place, sometimes, a portion of the ovary deformed for want of fecundation, and at other times, a glandular body. When this is the case with the male organs, we find in their place a portion of the filament, or a glandular body which indicates their disappearance.

But we find whole families, or nearly so, in which the flowers are unisexual, and where no rudiments of the abortive organs are perceived; whence several naturalists have concluded that there are flowers where one of the sexes is essentially wanting. There is no reason that this cannot be the case, and that flowers cannot be met with which are formed of only two or three verticils, one or two of which serve as the protecting organs, and the innermost only is changed into the sexual ones. However, I am inclined to believe that if this phenomenon take place in phanerogamous flowers, it is very rare; for there is hardly any family said to be unisexual in which we do not find flowers constantly hermaphrodite: such are the Elm among the Amentaceæ; *Melothria* in Cucurbitaceæ; *Agdestis* in Menispermeæ, &c. We even find individuals accidentally hermaphrodite in certain species in families which pass for unisexual ones: such are several Poplars and Willows among the Amentaceæ; the Hemp in Urticeæ, &c. As to families, such as the Coniferæ and Euphorbiaceæ, where we find no example of hermaphrodite flowers, we may consider them as presenting an abortion more constant than the preceding, or as being essentially formed of a smaller number of verticils.

There are other cases where the sexual organs cease to perform their functions, and take an extraordinary development. Thus the styles of the Anemone sometimes become large and petaloid by culture; the branches of the style of the Iris, although furnished with a

stigma in the form of a transverse fold, are usually in a petaloid state; a great number of double flowers also have their styles developed into petaloid laminæ; thus proving the peculiar analogy of the styles, stamens, and petals.

The degenerations of the male organs are still more frequent. When the anthers are abortive, the filaments are changed into laminæ perfectly like the petals of the plant: this is what we see in common double flowers. When the anthers themselves remain, although becoming sterile, it happens sometimes that they are developed in the form of horns: this happens in several Ranunculaceæ. The Columbine presents this very remarkably. By culture we obtain two double monstrosities: the one with all the petals flat, owing to the development of the filament and the absolute abortion of the anther, as *Aquilegia vulgaris stellata;* the other with all the petals horn-shaped, resulting from the non-development of the filaments, and the extraordinary increase of the anther, as *A. vulgaris corniculata.*

The degenerations of the petals are the more difficult to recognise, as they themselves are constantly in an intermediate state between the primitive one of a leaf and that of a stamen. Every form is met with in these organs. The principal modification is owing to the presence of certain glands, which cause the origin of spurs: it happens in certain gamopetalous flowers that the unequal union of the petals is very manifest, and produces different appearances.

The abortion of the petals is more difficult to reduce to general laws than the preceding phenomena. Let us first take the most simple cases. That there are plants, the petals of which are accidentally abortive, it is difficult to doubt: thus *Sagina apetala* sometimes presents very small ones, sometimes it is entirely devoid

of them. Thus a great number of apetalous plants are so analogous in their whole symmetry to those furnished with petals, that it is impossible not to think that their absence is only owing to their non-development. Let us observe here, that they are thus accidentally wanting only in polypetalous flowers, and that there is no authentic example known of an abortive corolla in gamopetalous plants, if it be not so, perhaps, in some cases where the stamens are wanting at the same time, as in *Gymnostyles* and *Fraxinus:* when the petals are abortive, there sometimes remains in their place either a petaloid rudiment or a glandular body. We also say that they are absent when they are accidentally changed into stamens, as in the singular variety of *Capsella Bursa pastoris*, of which M. De Jacquin has kindly communicated to me a specimen and a drawing, which I here give (Pl. 18, fig. 3, 4). In this monstrosity, which can be perpetuated by seeds, we find the flowers with ten stamens, instead of six of these organs and four petals: I have found an analogous fact in a monstrosity of the common Bean, where the two wings of the corolla were changed into stamens. We shall treat more at length upon this kind of transformation, and revert to the case where the petals are constantly wanting. This will form the object of the following Section.

Section VIII.

Of Monochlamydeous, or incomplete Flowers, or those which have but one envelope.

When a flower presents a single envelope, is it a corolla, calyx, a union of both, or an organ different from either? All these opinions have been maintained, and deserve to be examined.

Tournefort, who made the character of the calyx to consist in its being persistent, and that of the corolla in its being caducous, found himself compelled, from this false definition, to give different names to organs evidently similar in analogous plants: thus he called corolla in the Tulip the organ which he named calyx in the Narcissus. Linnæus did not attach any importance to this definition, perhaps on account of that which he had adopted; he admitted, in fact, that the calyx was the prolongation of the bark, and the corolla of the liber. This distinction is hardly capable of being maintained either in Monocotyledons, where there is neither liber nor bark, or in Dicotyledons, when the liber is nothing but the younger cortical layers. Thus in practice Linnæus usually called calyx that which was green, and corolla that which was coloured; thus the single envelope in Monochlamydeous Dicotyledons was, according to him, calyx in *Chenopodium,* corolla in *Daphne;* and in Monocotyledons, calyx in *Juncus,* corolla in the Liliaceæ; often he says "*calyx nisi corolla mavis,*" &c. Lamarck, in his first works, defined the corolla as the organ nearest the stamens, and consequently named all single envelopes as such; but he afterwards abandoned this opinion. These different modes of expression might perhaps suffice when it was

a question of purely artificial order; but it is important, as regards both the natural order of classification and the physiology and comparative anatomy of plants, to fix our ideas upon this subject, and to be able to compare together organs truly analogous.

Those who have paid any attention to this subject have thought that the floral envelope, when it is single, is not a corolla, because it is often green and foliaceous, and frequently adherent to the ovary, which true corollas never are, and because the corolla appears more disposed to be abortive than the calyx; I only truly know *Nemopanthes* of which it might be said with any reason that it has a corolla and no calyx, but this is simply because the latter is reduced to a circular rim.

Jussieu, uniting in the definition of calyx the conditions of Tournefort and Linnæus, has established that the floral envelope, when single, is always a calyx. This opinion cannot be called in question when it occurs in Dicotyledonous plants which belong to families usually furnished with calyx and corolla, but which are devoid of one of these organs; in this case it is evidently the petals which are absent, as, for example, in *Clematis*, the apetalous Capparideæ, Caryophylleæ, Rutaceæ, Rosaceæ, and Ficoids. The analogy with neighbouring genera evidently shows it; and if one wished to maintain that some of these organs could not be calyces because they are coloured, I would call to mind that the calyx, and even the bracts, of *Hortensia* and *Salvia splendens* are as much coloured as the most brilliant corollas; I would add, that these single envelopes perform the part of true calyces, both in bearing the stamens in calycifiorous plants, and not doing so in thalamiflorous ones, and in their being frequently adherent to the ovary, &c.

The question is more difficult when it takes place in

Dicotyledonous families which have constantly or usually a single envelope to the flower. Jussieu, deciding the question, has given them the name of Apetalæ, and to their envelope that of calyx; on account of the uncertainty which exists, I have decided to call these plants Monochlamydeæ, and their envelope a Perigone, neutral terms, which express a fact without declaring an opinion.

The reasons for which this envelope may be compared to a calyx, are:—1st, its extreme analogy with the calyces of plants which are accidentally devoid of petals; 2d, its frequent adhesion with the ovary; 3d, the greenish and foliaceous appearance of several; 4th, the analogy of structure of several monochlamydeous families with those usually furnished with petals, such as Amaranthaceæ with Caryophylleæ, Juglandeæ with Terebinthaceæ, Euphorbiaceæ with Rhamneæ, Elæagneæ with Combretaceæ, &c.; 5th, the existence in several, especially in Thymelææ, of small petaloid scales, which may be true petals.

On the other hand, I consider that the external surface of these single envelopes has all the characters of a calyx: it is usually green; it constantly presents stomata, even when it is coloured, as in the Marvel of Peru; it frequently bears hairs or glands analogous to those of the leaves, as in Elæagnus; but the inner surface almost always presents the characters peculiar to the sexual organs; it is coloured, has no stomata, and bears neither hairs nor glands analogous to those of the leaves. We might conclude from these facts that it is a calyx lined internally by the torus, or a petaloid expansion of it. This hypothesis would be confirmed by this consideration, that with the exception of the Amaranthaceæ, which must, perhaps, be placed among Thalamifloræ by the side of the Caryophylleæ, all the

other Monochlamydeous families have perigynous stamens, and the torus consequently adherent to the calyx. Finally, whether we say that it is a calyx, or that it is a double one with a petaloid lamina, all the consequences are found the same, and therefore the difference is of but little importance.

We shall now examine the envelope of Monocotyledonous flowers, and here we shall find some new difficulties. Desvaux, considering that it is always formed of two rows of pieces placed alternately, has proposed to consider the outer one as a calyx, and the inner one as a corolla. This mode of viewing it seems particularly authorized :—1st, by the structure of the Commelineæ, Alismaceæ, and several Amomeæ, where the outer row has a perfectly calycine appearance, and the inner one a perfectly petaloid one; 2d, because the æstivation of the two rows is often very different, as, for example, in *Tradescantia*, where that of the outer row is valvate, and that of the inner irregularly twisted. This manner of expression would often be advantageous for the clearness of descriptions; but as to the reality, it appears to me hardly admissible: in fact, in the majority of cases these two rows are perfectly similar, and especially in all Liliaceous plants with an adherent ovary, the two rows are equally united to that organ, whilst true corollas never are. It must then be admitted, that the two rows form part of a single envelope, which Linnæus calls corolla, Jussieu calyx, and I perigone.

The reasons which I have above mentioned, and especially the adhesion with the ovary, prove that it is not a true corolla. The idea of considering it as a calyx presents the same difficulties which I have shown in monochlamydeous Dicotyledons; and, moreover, in these two circumstances :—1st, that the stamens are most frequently hypogynous; 2d, that when the flowers

become double, which is frequently the case, the stamens are transformed into petals so similar to the pieces of the perigone that it is difficult not to believe that they are of a very analogous nature.

If we add to these reasons, that this envelope is often green on the outside and coloured internally, that it always has stomata on the outer surface and none on the innner, we shall perhaps be inclined to conclude, that this perigone is formed of a calyx lined, thus to speak, with a petaloid expansion of the torus. I have only given this opinion as a simple hypothesis; but I think that it is more prudent, in the actual state of the science, not to adopt terms which decide the question too clearly, and that it is well to retain for these doubtful cases of a single envelope a particular name. I have adopted, after Ehrhart, that of PERIGONE, which signifies, around the sexual organs; and following the analogy of the terms sepals and petals, I propose to give to the pieces of which it is formed the name of TEPALS.

Some authors, adopting my idea, have given the single envelope the name of PERIANTH; but I think it better to retain that of perigone:—1st, because that of perianth was understood by Linnæus to designate the true calyx; 2d, because this term, which signifies around the flower, would be more applicable to an involucrum than to an organ which forms part of the flower; 3d, because the word perigone has been proposed in this sense before that of perianth, and we ought always to avoid useless changes of nomenclature. The term being once admitted, we must apply to the perigone all that has been said of calyces and corollas, inasmuch as they are formed of pieces, sometimes free, at other times cohering; all that has been said of calyces, as regards their adhesion with the ovary; and all that has been said of petals, inasmuch as they are analogous to

the development of the filaments. Admitting this manner of viewing it, we shall understand how the perigone is sometimes adhrent to the ovary, or composed of parts opposite the stamens—characters peculiar to the calyx; whilst in other plants, it is free, odorous, has its lobes alternate with the stamens, and becomes double and multiplied by the abundance of the sap—characters peculiar to the corolla.

The perigone is sometimes reduced, by abortion, to a simple rudiment: this is observed among Dicotyledons, in the Euphorbiaceæ, and especially in those with the flowers in compact heads. It is this which happens among Monocotyledons in the Gramineæ, where the perigone appears represented by the lodicules; their number is ternary in *Bambusa* and *Glyceria;* sometimes the third is smaller, and its absence in several cases may result either from an abortion more or less complete, or from their intimate union.

Section IX.

Of the relative Position of the parts of one floral Verticil compared with that of another.

The position of the parts which compose the floral verticils is susceptible of every modification which results from each of them, being either between or opposite the pieces of the outer verticil. The first case, that is to say, that where each piece is between the two outer ones, is so much more frequent than all the others, that we may believe that it is the natural state, inasmuch as it is conformable to the disposition of the successive

verticils of leaves. Thus, the petals of flowers which are regular, and the parts of which are equal in number, arise usually between the sepals, the stamens between the petals, and the carpels between the stamens. But there are some exceptions to this rule: thus, we find the petals opposite the sepals in the Barberry; the stamens opposite the petals in the Primulaceæ, Myrsineæ, &c. As to the real position of the carpels, it has been much less studied than that of the other organs, and without doubt it would give some interesting characters in certain families; but the frequency of their abortion renders their observation delicate. Some examples recently observed, make me think that in perfectly regular plants, where the number of parts is equal in all the verticils, the carpels are always alternate with the sepals, whatever may be the position of the verticil nearest to them: thus, the carpels of the Crassulaceæ are alternate with the sepals, both in the genera *Crassula*, *Rochea*, &c. which have the stamens alternate with the petals, and in *Sedum*, *Cotyledon*, *Sempervivum*, &c. which have the stamens double the number of the petals; the one set alternate, the other opposite them.

The different dispositions of the parts of the flower may be modified by the number of rows of each verticil, or by the abortion of parts, or because, in several cases, there is developed a cluster of organs resembling that where there is usually found but one: thus, for example, in several Homalineæ we find a tuft of stamens situated in the angle of two contiguous sepals. The same thing takes place in the Myrtaceæ, in a very singular manner: thus, the bundle of stamens formed by the union of several, are opposite the petals in *Melaleuca*, and alternate with them in *Astartea*. Several double flowers present a fasciculated development, which deserves to be noticed: thus, it is not rare to find

bundles of petals arising from the place whence there ought to proceed but a single petal or stamen; this is what is very well seen, for example, in certain double Primroses; but this peculiar case of multiplication leads us to examine this subject in a general manner.

Section X.

Of the Multiplication of the Floral Organs.

The organs which compose the flower may be increased, as to their number, in two ways:—

1st. The usual number of verticils may be increased by new verticils, like one of them, which are developed in a regular but supernumerary manner.

2d. The number of pieces of one verticil may be increased by the unusual development of organs resembling those of which it is composed.

These two phenomena have been indifferently called by the names of Doubling or Multiplication; but I prefer the latter term, which appears to me less hypothetical than the other.

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§ 1.—The Multiplication of the Rows of Verticils.

The multiplication of the rows of one verticil is a fact which is accidentally observed in several plants, and which may affect all the organs. Thus,—

1st. As concerns the Bracts, there is cultivated in gardens a variety of the Pink, which some call *Dianthus*

Caryophyllus imbricatus, and in which the number of bracts, situated at the base of the calyx, instead of being four, *i.e.* two pair, we find fifteen or twenty pair, crossing each other at right angles, and imbricated; on account of this great multiplication, the flower is frequently not developed. It appears to result from the premature transformation of the upper leaves into bracts.

2d. As regards the PERIGONE, we find in gardens a variety of the white Lily, the tepals of which, instead of being in two rows, and six in number, are disposed in an indefinite number of imbricated verticils. In this case the stamens and carpels are absent, or transformed into tepals; but we cannot say that the phenomenon is simply owing to this transformation, for the number of verticils is much greater than the whole usual number of the floral organs; it is, then, a multiplication of the normal number of verticils. In another monstrosity of the Lily, we find the parts of the perigone multiplied, and the stamens also existing. All Monocotyledons with double flowers present, here and there, analogous facts. The inner tube, or, as it is called, the crown of the Narcissus, may be classed here.

3d. The multiplication of the rows of the CALYX, properly so called, is more delicate to confirm, because of the difficulty of exactly distinguishing the supernumerary rows of sepals from simple bracts. Some calyces of the Berberideæ and Ericaceæ appear to afford examples of this sort.

4th. The COROLLA frequently has multiplied rows: one of the most curious examples is that which *Datura fastuosa* (Pl. 18, fig. 5) presents, where we frequently find two or three corollas inserted, as it were, into one another, and having their lobes alternate. The same phenomenon has been observed in several Campanulas, some Labiatæ, &c., and it seems possible in all gamo-

petalous flowers. When this multiplication is limited to one or two inner rows, it happens then either that the inner corolla bears the stamens as usual, or that they are absent. In this last case we may say that the corolla results from the simple transformation of the stamens into petals; but in the first it is evident that there has been a multiplication of the usual rows. The same phenomenon is also met with in polypetalous flowers, as the Pink, &c.

5th. The STAMENS very frequently present this multiplication of rows, especially in the genera where the number of rows is naturally considerable; thus on comparing together several flowers of the same species of Poppy, we find that the number of their verticils is very variable.

6th. Finally, the CARPELS, which are less numerous and more central, rarely present this accidental multiplication; however, from time to time we find double rows among the Ranunculaceæ and Rosaceæ with verticillate carpels. I have met with a very remarkable example of this accident in *Gentiana purpurea:* I give a figure of it in Pl. 18, figs. 6, 7. Here we see two rows of ovuliferous carpels; the outer of four, the inner of two.

But if all the floral organs can accidentally present the multiplication of the rows of which they are usually composed, is it not likely that this phenomenon may be constant in certain plants, perhaps in certain families? And are not the genera, such as *Nymphæa*, *Mesembryanthemum*, &c, where the parts of the flower are presented in a very great and indefinite number of rows, evident examples of this opinion?

§ 2.—The Multiplication of Parts of a Verticil.

The second kind of multiplication of the floral organs is that where the usual number of the parts of a verticil or row is increased. This may take place in different ways:—

1st. The absolute number of all the verticils of a flower may be augmented by the addition of one or two pieces to each: thus, it is not rare to find flowers of the Colchicum with seven or eight lobes, and as many stamens; flowers of the Rue and *Philadelphus* with sometimes four, at others five parts, &c. In these cases we must first examine if it be not the higher number which is the usual state, and then the diminution of number is classed among the cases of abortion; but in the contrary case, the multiplication appears to result from the natural union of two flowers, as I have elsewhere explained.

2d. In the place of an organ apparently single, but in reality composed of several intimately united, we may accidentally find them becoming free. Dunal made known a curious example of this in *Laurus nobilis.* We know that the stamens of this tree have on each side of the lower part of their filaments a glandular bifid body, borne on a short filament intimately united to that of the stamen; it appears that this body is an abortive stamen, and consequently that of the Laurel is a bundle of three united, the two lateral ones being abortive: it happens, in fact, that the three stamens are sometimes developed, and the whole number is found tripled, and none of them bears the glandular body on its filament. Several peculiar facts of the history of polyadelphous flowers appear to coincide more or less clearly with this example, which may be considered a complication of union and abortion.

3d. In the place where, in the usual course of vegetation, there arises a single organ, we sometimes see a cluster of analogous ones developed. Thus, each of the stamens in certain monstrosities of the Primrose, instead of being changed into a single petal, is transformed into a cluster united at the base. It seems that this fact is analogous to what is constantly found in certain flowers in which we see a cluster of organs united where, from analogy, we ought to find but one: such are the bundles of stamens alternate with the petals in *Melaleuca* and several species of *Hypericum*.

4th. A fact analogous to the preceding appears to take place in certain cases, with this difference, that the multiplied organs which, from symmetry, appear to replace a single one, are completely free at their base; thus, in *Lagerstromia*, we count five large stamens alternate with the petals, and four or five small ones which, situated opposite each petal, seem to represent by their union a single stamen. This fact, combined with the abortion of the large stamens, seems to render intelligible the structure of several Byttneriaceæ. This class appears to be connected with the preceding by the example of the Cruciferæ, where the two pair of large stamens, sometimes free, sometimes more or less united, seem, from symmetry, to replace a single stamen.

5th. Lastly, it sometimes happens that the two parts of an organ are so separated at their base as to appear to form two distinct ones. Thus, *Impatiens Noli-tangere* has four petals and five stamens—three alternate with the petals, and two springing side by side at the point where the fourth ought to arise in the regular state. For, the three solitary stamens between the petals have two-celled anthers, and those in a pair have them unilocular, and seem consequently to be a stamen divided into two. The term of doubling applies very well to

this case; that of multiplication represents better the preceding, where all the supernumerary organs result from all the parts of a single organ. It is true that they are generally of smaller size, but it is likely that this is referable to the general law of vegetation,—that where a large number of organs is produced within a given space, they find there less nourishment, and take a less degree of development.

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§ 3.—General Examination of Double Flowers.

It is customary to designate under the name of DOUBLE FLOWERS *(flores pleni)* all those where all the different floral organs, or one or two of them, take the appearance of petals, and those where the number of petals is, or appears to be, increased by any cause.

Double flowers ought, in my opinion, to be classed in three divisions:—

1st. PETALODEOUS FLOWERS *(flores petalodei)*, that is to say, those which become double by the simple development into petals of all or any of the floral organs: such are those where this development affects the bracts *(Hortensia)*, the calyx *(Primula calycanthema)*, the stamens *(Rosa, &c.)*, or the carpels (var. of *Anemone nemorosa*, &c.) We may also distinguish two cases among petalodeous flowers which proceed from the development of the stamens—viz. that where it takes place by the dilating of the filament and the entire abortion of the anther; and that where the filament remains in its natural state, and the cells of the anther are developed into petals. In the first case, which is by far the more frequent, the supernumerary petals are always flat; in the second they are horn-shaped. The Ranunculaceæ present this double mode of transformation in a singular

manner; the Clematideæ double after the first mode, the Ranunculeæ after the second, and the Helleboreæ present both. There are species even which become double in both ways: thus, *Aquilegia vulgaris*, when its filaments are changed into flat petals, forms the variety called *stellata;* and when its anthers are changed into horn-shaped ones, it forms the variety *caniculata* when the horn is erect, and *inversa* when it is reversed by the torsion of the filament.

2d. MULTIPLIED FLOWERS *(flores multiplicati)* are those where the number of petals is augmented by the increase of the number of rows of floral verticils, or of parts of these rows, and their transformation into petals. In the preceding class the number of parts was not augmented, and there was only transformation; here there is increase in number, and transformation. All the examples mentioned in the two first divisions of this section belong to this class.

3d. PERMUTED FLOWERS *(flores permutati)* are those where the abortion of one of the sexual organs causes a remarkable change in the form or dimension of one of the floral envelopes; thus, the abortion of both or one of them in the Compositæ frequently causes a change of form in their corolla; it sometimes, remaining tubular, becomes larger than ordinarily, as is seen in some varieties of Asters, African Marigolds, &c.; sometimes it is transformed into a flat strap, which is the most usual case in the Compositæ called double in gardens. Similar phenomena are met with in the Guelder Rose *(Viburnum opulus)*, the sterile flowers of which have the corolla larger than the fertile ones: in the natural state the lateral flowers alone present this phenomenon; but in the cultivated variety all are enlarged, owing to the abortion of the sexual organs.

Thus the name of double flowers is applied, in ordi-

nary language, to very different phenomena. Organography instructs us to class them, to compare them with natural phenomena, and to refer them to known analogies; but it will be for Physiology to determine, if possible, the causes of these different metamorphoses, which are less unworthy than has been thought of the observations of the Botanist, since they are intimately connected with the study of the organic symmetry of plants.

Section XI.

Of the Inequality of Parts in a Floral Verticil; or of Irregular Flowers.

The different verticils which compose a flower, may be, with regard to one another, of very unequal size: some may even be entirely wanting, without the flower ceasing to be regular; for each of its portions, taken from the centre to the circumference, resembles the others; but the name of Irregular is given to flowers in which one or more parts of a verticil are different from the others in size, form, direction, situation, or degree of cohesion.

In order to form a just idea of the symmetry of flowers, we must always endeavour to refer irregular ones to regular types, from which they seem to be degenerations. Each family appears to have a regular type, which is its natural state, and from which they differ, either accidentally or constantly, from different causes. When these causes result from foreign influences on the

plant—as, for example, mutilations owing to culture, the unequal action of light, the pressure of neighbouring bodies, &c.—then the irregularities are purely accidental; when, on the contrary, it results either from the mode of development of the neighbouring organs, or, what is more frequently the case, from the disposition of the flowers, either with regard to each other or to the stem, then the irregularity is constant, and the flower only presents its natural state in very rare cases, and which may, in their turn, be called accidental.

The disposition of the flowers is, of these causes inherent in plants, the one of which we are the best able to appreciate the effects. Thus, for example, when they are near together, either in compact spikes or racemes along the axis, or in heads or umbels, the inner or upper part of the flower, *i. e.* that which is nearest the axis, is restrained in its development by the pressure of the flowers against the axis or against each other; whilst the other side is more at liberty; whence it results, that there is sometimes a complete or incomplete abortion of some of the parts bordering upon the axis, and the development of the opposite side; sometimes a more lengthened and complete union of the parts in the neighbourhood of the centre, whilst those on the opposite side are more free; sometimes a union of the two facts which I have mentioned.

The general result of the pressure is counterbalanced, sometimes even disguised, by another cause: viz. in a flower when one of the parts of a verticil is entirely or partly abortive, the corresponding part of the neighbouring verticil takes a greater development than usual, because it gains advantage either from the place or nourishment which the other would have made use of; whence it results, that it is extremely rare that the irregularity of one of the floral organs does not produce an

irregularity in the others. Let us follow the application of these principles to the different organs of the flower, and to the different kinds of irregular flowers.

The sepals, in consequence of their foliaceous nature and external position, are more liable than all the other organs to the action of external causes; thus we find irregular calyces even in flowers otherwise regular; thus one of the free portions of the sepals of *Mussænda* and *Pinckneya* is spread out into a limb much larger than the other. The same phenomenon takes place, although in a less decided and constant manner, in Roses.

The petals present inequalities of size, which result from the unequal development of the neighbouring sepals, or from the different modes of their metamorphosis.

The pieces of the calyx, corolla, or perigone, are often united together in unequal degrees; when the inner or upper pieces are united at a different point from where the lower ones cohere: it results that the flower has two lips, an upper and lower one; and it is so true that the flowers with a labiate calyx or corolla owe this irregularity to their position with regard to the axis, that we never find the lips lateral, but always superior and inferior, as we see in the labiate calyces of the Papilionaceæ, Labiatæ, Scrophularineæ, &c., in the corollas of the two last families, or the perigones of the Orchideæ, &c.

The stamens are organs very subject to irregularity, even in plants where the rest of the structure is regular: it must, however, be remarked, that they may be unequal with regard to each other without being irregular; thus, in several flowers which have the number of stamens double that of the petals, they are alternately long and short, early or late in coming to perfection; and in this case, it is those which alternate with the

petals which are the longest, most forward and constant. When they are in several rows, the rows, when compared together, are sometimes very different in size; but as long as all those of the same row resemble each other, the flower is regular. The inequality of the stamens may result either from unequal degrees of cohesion with the corolla, calyx, or perigone; from unequal degrees of cohesion with each other; from the inequality of the length of the filaments; from the unusual development of these filaments; from the total abortion of the filaments or anthers, or from their being deformed.

The place of the stamens being always determined with regard to the petals, we may, on attentively studying them, easily perceive the total abortion of some of them; thus, when a flower has the corolla with five petals, free or united, if we observe that the stamens are alternate with or opposite the petals, we shall immediately perceive if there be a vacant space; as takes place, for example, in the Labiatæ and Scrophularineæ: in this case, the place is either completely vacant, or marked by a small glandular point on a little filament; and it is so certain that these are the rudiments of undeveloped stamens, that it is not rare to see certain flowers with them developed into true stamens. When this phenomenon takes place, the rest of the flower also becomes regular: this accident, or rather this return to symmetry, is well known in *Linaria vulgaris;* but it is not limited to this plant, as was at first thought: it is found in several species of the genera *Linaria, Antirrhinum, Digitalis, Sesamum, Galeopsis, Viola, Orchis;* and we are authorized in considering it as a phenomenon common to all irregular flowers.

All these same accidents, especially that of total abortion or nearly so, are common in the carpels. When

among these there is but a small number abortive, and there remain at least two complete ones, the pistil still presents the appearance of regularity if considered with regard to itself; but it appears irregular when compared with the number of the other parts of the flower. Thus, the Cistineæ, which have five sepals, five petals, and five carpels, are regular; those which, as *Helianthemum*, with the same floral numbers have but three carpels, have the fruit intrinsically regular, but relatively irregular. When the number of carpels is reduced by abortion to one, this one always presents traces of irregularity; thus, when it has several seeds, they adhere laterally on the side nearest the axis of the flower, as is plainly seen in the Leguminosæ. It is remarked, that when these plants have accidentally several carpels, *i. e.* when the abortion is less complete, the second, when it exists, is situated precisely opposite the first, having the seminiferous suture also directed towards the centre, so that a regular fruit is the result; I have observed this in *Gleditsia.* The drupaceous Rosaceæ (Amygdalaceæ) also have a single carpel by abortion; and we find Cherries and Plums which have accidentally either two carpels united, or several free. Auguste de Saint-Hilaire found in Brazil a Mimosa with five carpels; and when we compare the structure of the Leguminosæ, thus considered, with the Spiræaceæ among the Rosaceæ, we shall perceive that these two families hardly differ more than in the abortion of the carpels being frequent in the Leguminosæ, and rare in the Rosaceæ.

In carpels which appear to have but one seed, the irregularity is visible in two respects:—1st, It is almost certain that the seeds are only solitary by the more or less early abortion of one of the ovules;—2d, From the manner in which the seed is situated, there must be some irregularity in the carpel. Is it attached laterally, as in

the Leguminosæ? the irregularity is evident, for the placenta is lateral. Is it attached to the base of the carpel, as in the Compositæ? the pistillary cord follows one of the sides of the pericarp, and causes an irregularity. Is it attached to the apex of the carpel, as in the Dipsaceæ? the vessel that supplies it with nourishment passes along one of the sides of the carpel, and makes it necessarily irregular. Thus, every monospermous carpel, every solitary carpel, is naturally a deviation from the symmetrical order, and, consequently, an irregularity most probably caused by abortion.

Section XII.

Of the Primitive Disposition of the Parts of a Floral Verticil; or of the Æstivation.

The complete and regular flower is, as we have seen, composed of at least four concentric verticils, each formed of several pieces, the relative disposition of which we are about to consider. The rapid development of these different organs at the period of flowering is such, that we cannot judge of this primitive disposition unless we study it in the buds. Linnæus, who compared it with the vernation of leaves, has given it the name of Æstivation. Richard has proposed to substitute that of Prefloration; which perhaps would be preferable, if it were worth while to change a term which is not erroneous.

This disposition of the parts is especially important to be observed in that which relates to the envelopes of the

flower, viz. the sepals, petals, and tepals, where the pieces, free or united at the base, form the calyx, corolla, and perigone. Let us first examine the disposition of flowers strictly regular.

We must first observe whether the parts of an organ are in one row, or if they be in two or more; when they are strictly verticillate in a single row, there happen four cases:—

1st. These parts may be disposed in a perfect circle, each of them being flat or slightly convex; then they all touch by their margins without overlapping each other, or without being folded inwards: this is called Valvate Æstivation, because it is analogous to the disposition of the valve of Pericarps, (Pl. 19, figs. 2s, 3s, 4s, 15p.) The sepals of the Lime-tree and of most Clematideæ, the petals of the Vine and of the Araliaceæ, the outer tepals of *Tradescantia*, and the leaflets of the involucra of *Othonna Cheirifolia*, present examples. The pieces of integuments with valvate æstivation are usually remarkable on account of their margins being thick, indurated, sometimes slightly glutinous or velvety in their infancy; circumstances which contribute towards retaining them in this position.

2d. These same parts may be disposed in a perfect circle, but each with its margin folded inwards; they appear valvate externally, but when we open the bud, we see the fold of each piece. This constitutes Induplicate Æstivation (Pl. 19, fig. 6); it has much affinity with the preceding, as it is sometimes found in plants very near, as regards their form, to those with valvate æstivation, such as *Clematis Viticella:* the portion folded inwards is usually thin and membranous.

3d. We may, from analogy, admit a Reduplicate Æstivation, which takes place when the pieces are

folded or rolled backwards, as seems to happen in the petals of some Umbelliferæ.

4th. The parts of a verticil may be disposed in an exact circle as to their position, but each of them slightly twisted upon its axis, so that by one of its sides it overlaps one of the neighbouring ones; and its other side, being a little more interior, is overlapped by the other one which is next to it. This disposition, which is called TWISTED or CONTORTED ÆSTIVATION, (Pl. 19, figs. 2p, 4p, 5p,) is rare in envelopes which have their pieces perfectly free; it is seen in the petals and sepals of the Flax, in the petals of the Pink and of the Malvaceæ; but it is much more frequent in the free portions or lobes of gamopetalous corollas, as in the Apocyneæ and Rubiaceæ.

When the parts of a regular verticil are in two or more rows, *i. e.* when the same verticil is double, &c., it may also present several cases:—

1st. If the parts, placed exactly in the same direction as regards the axis, be alternate with one another, there results the ALTERNATE ÆSTIVATION, (Pl. 19, fig. 14,) where the pieces of the second row exactly alternate with those of the first, and those of the third with those of the second, &c.; this is seen in the tepals of the Liliaceæ, the petals of the Nymphæaceæ, &c. Each of these rows may itself present one of the preceding dispositions; but as the pieces are more distant, we are rarely able to recognise it with precision.

2d. Under the name of IMBRICATE ÆSTIVATION, (Pl. 19, figs. 9, 11,) are generally confounded all the cases where the envelopes, being in several rows, have no determined order, and where the pieces overlap each other as the tiles on a roof. We see this in the involucra of most Compositæ, in the petals of most double flowers; but it is probable that we confound here, in the same

class, dispositions really distinct. When the pieces are in two rows, and the outer one is very short compared with the inner one, we designate this disposition by the name of CALYCULAR ÆSTIVATION; but this relates to the proportion, and not to the position of the parts.

3d. It is possible that there exists in reality an OPPOSITE ÆSTIVATION, *i. e.* when each of the pieces of one row arises exactly opposite that of the first row; but the examples which might be referred to this class are obscure and uncertain; such would be, for example, the inner petals of *Epimedium* and *Leontice,* if we may really consider them as distinct pieces of true petals.

The cases which I have enumerated seem to me to be the only ones which exist in flowers strictly regular; but there are cases of slight irregularities, which it is usual to class among æstivations. I ought, perhaps, to have mentioned them in the preceding section, but I hope to do it more clearly in reserving them for this.

When the parts of the calyx or corolla are not situated exactly in the same manner with regard to the axis, there is an irregularity, and then one or some of these parts have a tendency to overlap the others during the prefloration; it is this that a great number of botanists designate collectively by the name of Imbricate Æstivation, a term which, although become customary, has the inconvenience of being taken here in a very different sense from what is explained above; and it would be advantageously replaced by that of IRREGULAR ÆSTIVATION, if we wished to have a collective term. It must be remarked, in fact, that this æstivation only exists in irregular flowers, or in those having a tendency to become so; for it is a deviation from the symmetrical order. We may distinguish several cases sufficiently constant to deserve, perhaps, a special designation.

Thus, among 5-parted flowers, we often see the pieces

of the calyx, corolla, or perigone, so disposed that there are two exterior, one or two entirely interior, and one or two intermediate, that is to say, half covered by one side of one of the outer ones, and overlapping by the other margin one of the inner ones; this is very evident in the calyx of the Rose, and I have called it QUINCUNXIAL ÆSTIVATION (Pl. 19, figs. 10, 12).

The flowers of the Papilionaceæ present one of their petals more exterior, and embracing all the others, two intermediate ones face to face, and two inner ones also face to face; this constitutes VEXILLARY ÆSTIVATION, (Pl. 19, fig. 8.)

The variety of these irregular æstivations is very great, being connected with the irregularity of the flowers; and in a great number of cases it may seem as a sign whereby to discern flowers perfectly regular, or more or less irregular. We may see different examples in Pl. 19, figs. 7, 9, &c.

Before quitting this subject, I ought also to remark, that the æstivation of the parts of the calyx and corolla have not any necessary affinity, even in the more regular families: thus, the æstivation of the Malvaceæ (Pl. 19. figs. 2, 7) is valvate in the calyx, twisted in the corolla; that of the Linaceæ and Cistineæ (Pl. 19, fig. 5) is twisted in both organs, but the torsion of the corolla is in a different direction from that of the calyx. This fact, with a multitude of others, tends to prove, that it is contrary to the nature of things to consider the calyx and corolla as two rows of one organ which is called perianth; but that they are, in reality, organs as different as all those of which the flowers are composed. There are perigones of which the parts are in two rows, and each row has a particular æstivation; such is the flower of *Tradescantia Virginica* (Pl. 19, fig. 3), where the outer row is foliaceous and valvate, and the inner

petaloid and rumpled: this seems to confirm the opinion of Desvaux, who considered the outer row as the calyx, and the inner the corolla. But, besides the reasons above mentioned against this opinion, it must be added, that the rumpled æstivation results only from an extraordinary development of the organs. Thus, the petals of the Poppy (Pl. 19, fig. 1), which are rumpled in æstivation when examined collectively, appear evidently alternate when examined separately, especially in double flowers where their number diminishes the rumpling.

The relative position of the stamens with regard to each other has less apparent influence upon the structure of the flower, seeing that the form of these organs always causes them to have sufficient space to develop in without overlapping; they only present, in this respect, differences in the number of concentric rows, the proportion of their size, the number of each row, and the degree of their cohesion, of which I have elsewhere spoken. I have already treated sufficiently upon the position of the carpels.

The direction of the organs forms also part of the history of their prefloration. Most of them spring erect, as in all the examples of æstivation which I have mentioned; but there are some folded or rolled inwards in a remarkable manner; thus, the calyces of the Valerians and *Centhranthus* have the limb rolled inwards upon itself, so as only to present, at the period of flowering, a kind of ring which is developed at the fall of the corolla: this is INVOLUTE ÆSTIVATION. The stamens of the Melastomaceæ have their filaments folded upon themselves, so that the anthers are pendent in the interior of the bud; this is an example of REPLICATE ÆSTIVATION. The carpels of *Spiræa ulmaria,* and still more those of *Helicteres,* are twisted spirally upon one another, in the manner of twisted æstivations;

but which must be considered as a Spiral Æstivation, seeing that their margins do not overlap. The bundle of stamens of *Inga Zygia* presents also an extremely distinct and extraordinary spiral torsion. Several styles, especially in the Leguminosæ, are rolled crossways upon themselves, or spirally upon the same plane, so as to resemble the disposition of circinnate leaves, and to deserve the name of Circinnate Æstivation; for example, the style of *Sabinæa*.

Section XIII.

Of Flowers united together.

Among the causes which tend to conceal the true symmetry of flowers, there is one which, although very accidental, deserves to be mentioned; I speak of the union of neighbouring flowers.

Sometimes two neighbouring peduncles are united so intimately, that they appear to make but one, terminated by two flowers: this happens naturally in the section of the Honey-suckles which have two-flowered peduncles; it happens accidentally in several trees, such as the Cherry, Apple, (Pl. 21, figs. 1, 2,) &c., and in *Centaurea* (Pl. 21, fig. 3).

Not only can the pedicels be united, as in the preceding case, but two or more neighbouring ones may be so as to form but one, which then presents more or less evident traces of this union. I have remarked this phenomenon very clearly in certain plants of *Galeopsis*, where the summit of the stem was abortive, and where was found a terminal flower formed by the union of two

neighbouring ones: this flower is larger than ordinarily, and almost regular; its calyx, corolla, and stamens present every number, from the natural one to double that number.

An analogous phenomenon appears to take place in some Tomatoes (*Lycopersicum*). Dunal has shown in detail, that the singular appearance of these ovaries, and the multiplication of their cells, so contrary to the ordinary state of the Solaneæ, results from the flowers being formed by the union of several.

There are some plants, where the union of the flowers only takes place by the calyces, which, in this case, are themselves adherent with the ovaries and bracts: this happens in *Gundelia* and *Opercularia*, and changes these capitula, composed of several flowers, into a mass, where during flowering we perceive the corollas distinct, but where we find apparently only a multilocular fruit resulting from the union of all the partial ones. We shall revert to this subject on speaking of Fruits.

Section XIV.

Of the absolute Number of the Parts of each Floral Verticil.

We have seen that flowers are composed of pieces disposed in several concentric verticils, and that (with some exceptions) the pieces of each verticil alternate with those of the preceding; whence it results, that if we omit irregularities from partial abortions, the

absolute number of organs of the same name is usually determined by the number of similar verticils which are developed. Thus, when there are two rows of stamens, their number is double that of the petals; when three rows, triple; and so on. A second cause of variation in the relative number, which I have already mentioned elsewhere, is, that sometimes, in the place which it would seem ought to have been occupied by only one stamen, a bundle of them is developed; but even in this case, the number is a multiple of the petals or sepals. Lastly, plants frequently present a more remarkable, and, if I may so say, a more intimate kind of numerical aberration. It is not rare to find upon the same plant of the Rue, flowers with four sepals, four petals, eight stamens, and four united carpels; whilst others have five sepals, five petals, ten stamens, and ten carpels. We remark in this case, and in all analogous ones, that the flowers of the centre of cymes, which are developed first, are five-parted, and the following four-parted, and Linnæus has established as a rule in his system, founded upon the number of parts, that it is always by the first developed flowers that the number ought to be fixed. The examples of this kind of aberration, which affects at the same time all the verticils without deranging the symmetry, are repeated so frequently, that Linnæus used to express them by this phrase, "*Quinta seu quarta pars fructificationis interdum additur.*" We find facts of this kind in the Syringas, which have their flowers sometimes on a quaternary plan, sometimes on a quinary one; in *Asperula*, the flowers are sometimes three-parted, sometimes four-parted, &c. This phenomenon is entirely analogous to that which we have observed when speaking of the verticils of leaves, which are so liable to vary in number; we should say that a branch, whether furnished with verticillate leaves, or with verticillate floral parts,

is, as it were, composed of several fragments united longitudinally, and that symmetry always exists even when one of these fragments is wanting. A monstrosity of *Iris Chinenis* seems to support this theory; we know that the flower of this plant is formed upon the ternary plan, *i. e.* that it is composed, 1st, of two verticils of three leaves, transformed into lobes of the perigone, and united at their base with the ovary; 2d, of a verticil of three stamens; 3d, of a verticil of three carpels, united together, and also to the perigone. But in the example to which I allude, the flower is only composed of two-thirds of these organs, the perigone is in two rows of two leaves, and it has but two stamens and two carpels; but the other third, thus to speak, remains behind, half developed, and we find the rudiments of it very visible below the flower.

Does not this, which we have clearly seen in this case, because of the abortion not being complete, evidently exist in the cases where the abortion is more complete and regular; as, for example, when the flowers arranged in a quinary manner in the Rue, Syringa, &c., pass to the quaternary plan? Is it not also to the same cause that we must refer the cases where flowers, belonging by their analogies to a certain class, have a less number of organs than they ought to? Thus, for example, all the Asparagi are upon the ternary plan; and if *Mayanthemum* appears organized upon a binary one, it is probable that a third of its organs are constantly abortive, as we have seen to take place accidentally in the Iris. If several Myrtaceæ, Rubiaceæ, &c., present a quaternary plan, whilst others have a quinary one, is it not that a fifth of their organs is abortive?

We may consider that the two great classes of plants have their floral verticils composed of a determined number of pieces—Monocotyledons three, Dicotyledons

five. The great majority of facts corresponds to this rule, and I have little doubt that the exceptions will come to be arranged in proportion as we know more of the true symmetry of plants, and the great action of abortions. We have already seen that several of these exceptions are explained :—

1st. By the system of abortions of which I have spoken.

2d. By the union of several partial organs : thus, for example, if the flower of the Gramineæ appears to present a spathe with two valves, it is most probably because the inner valve is formed by the union of two.

3d. The exceptions, with an excess of parts, may be explained by the union of neighbouring flowers : thus, the flowers of *Paris* may, with sufficient truth, be considered analogous to those of *Trillium*, but united in pairs. We remark, in fact, that *Paris quadrifolia* presents the parts of each verticil in every intermediate number between three and six ; and *P. polyphylla*, which presents a still greater number, may result from the union of three or four ternary flowers.

Section XV.

Of Nectaries.

There are few terms which have been so much abused as that of Nectary. In its strict sense it means every excretory gland situated upon one of the floral organs, and the juice which it secretes bears the name of Nectar. Linnæus made use of this term to designate every kind

of gland, tubercle, or appendage, which, placed in the flower, did not seem to him to be an integrant part of one of the ordinary floral organs; since then, Botanists, perceiving the very great difference of objects united under this common designation, have endeavoured to class them separately, and have given them particular names, often more than was necessary. I shall here examine the nectaries in a general manner, first, with regard to themselves, and afterwards as concerns their connexion with the organs which bear them.

The excretory glands which are observed upon flowers, deserve a common name, principally because, whatever be their position, or the peculiar nature of the juices of each plant, or the form, size, and texture of these glands, they all secrete a more or less honey-like juice, which presents a very similar nature in all known plants,—a remarkable circumstance, which sufficiently proves an analogy of structure in all the glands which produce nectar.

The nectaries, in regular flowers, may be found placed on all the organs, but in a symmetrical manner. Their most usual place is upon the torus. Sometimes they form there distinct tubercles, the number of which is connected with the parts of the flower; for example, in *Parnassia*, the Crassulaceæ, &c.: they are situated upon the opposite sides of the flower in the Cruciferæ: sometimes the whole surface of the torus seems transformed into a glandular and nectariferous surface; for example, in *Cobœa*.

Sometimes they are placed symmetrically on the ovary; such are the three glands in the Hyacinth. Elsewhere, the parts of the corolla, calyx, or perigone, bear nectariferous glands, either on their inner surface, as those at the base of the tepals of *Fritillaria imperialis*, or on their outer surface, as in the calyx of the

Malpighiaceæ. The stamens also frequently bear nectariferous glands, particularly on the anthers or connectivum, as in *Adenanthera*, *Prosopis*, &c.

In all these examples the symmetry of the flower is not in the least altered, because the nectaries are placed regularly; but it very frequently happens, that we find in irregular flowers the nectaries so placed as to have no connexion with the symmetry. Is it the presence of these irregularly placed nectaries which causes the irregularity of the flower, or is it the irregularity of the flower which causes that of the nectaries? It is probable that these two causes are each true in certain cases, but we can only observe the concordance of the facts without determining which is the cause of the other. Thus, in a great number of irregular gamopetalous corollas, such as the Labiatæ and Scrophularineæ, we find upon the torus a nectariferous gland, placed upon one side of the ovary, but wanting on the other.

It frequently happens that when one sexual organ is abortive, its place is occupied by a nectariferous gland. Thus, in the Scrophularineæ, the place of the abortive stamen is often occupied by a gland; in several monœcious or diœcious plants the pistil is replaced in the male flowers by a nectariferous gland.

The nectaries upon the inner surface of the corolla are always superficial, and they often cause a cavity there, which, seen from the exterior, forms a kind of knob or spur. It is in this sense that Sprengel has given these organs the name NECTAROTHECA; thus, the base of the spur of Linaria, the violet, &c., always presents a nectary more or less developed; and when these flowers become regular, each of their spurs contains a nectary.

The genus *Parnassia* has very remarkable nectaries.

There is raised from the torus, between each of the five stamens, a cylindrical filament, with three, five, seven, or nine branches, according to the species, and each branch is terminated by a globular nectariferous gland: is this a simple form of nectary, or an indication of a bundle of abortive stamens? It is impossible to affirm any thing upon this subject.

The nectar secreted is sought after with avidity by bees and most sucking insects, which feed upon it. In endeavouring to reach it, it frequently happens that they excite or shake the stamens, and cause or accelerate fecundation; it may also happen that these insects on coming out of a male flower charged with pollen, bear it either upon the female ones of the same species, which they fecundate, or upon the flowers of analogous ones, by which they cause cross fecundations.

Section XVI.

Comparison of Foliaceous and Petaloid Parts.

We have seen, in describing the structure of each of the floral organs, that the one kind resemble true leaves in their intimate structure, their green colour, the presence of stomata, and the faculty of exhaling oxygen; such are the bracts, sepals, and most ovaries: the others are of a more delicate tissue, adorned with various colours, devoid of stomata, and incapable of exhaling oxygen; such are the petals, stamens, styles, and some ovaries. It is necessary now to examine to what point these limits are distinct. Let us first commence with the

cases where the usually foliaceous organs are found in a petaloid state.

The sepals frequently take the colouring and texture of the petals. In this case, when the two organs coexist, there is no doubt upon their distinction; thus, the calyx of a cultivated variety of the Primrose, *Primula Calycanthema*, is expanded into a coloured and petaloid limb, so that the flower seems to have two corollas. One of the lobes of the calyx of *Mussœnda* and *Pinkneya* is dilated into a petaloid limb, whilst the others retain their ordinary dimensions and appearance. In several genera of the Leguminosæ, Labiatæ, Verbenaceæ, &c. the calyx is more or less coloured, without our being likely to confound it with the corolla. But, if at the same time that the calyx is coloured, the petals happen to be wanting, or to take an unusual form, this calyx is frequently taken for a corolla. This occurs in *Anemone* and *Clematis*, where the petals are absent; in *Aquilegia* and *Delphinium*, where they exist, but deformed and rudimentary. In all these cases, the calyx, although coloured, is a true calyx, and it may be recognised either by analogy with neighbouring genera where the two organs exist, or by the study of double flowers.

It sometimes happens that the bracts themselves, although more distant from the petals, participate in the same tendency, and are coloured wholly or in part, accidentally or constantly; but this phenomenon never happens but when the calyx is coloured. Thus we find now and then individuals of the Anemone, where the involucrum is partly foliaceous and partly coloured: the bracts of several Liliaceæ, Leguminosæ, &c., and the involucra of several Umbelliferæ present the same fact more or less constantly. The bracts of *Salvia splendens*, *Monarda*, and several other Labiatæ, are ornamented with the most beautiful colours. The involucrum of

Cornus florida is so large, so coloured, and enjoys so much the function of petals, that it has given this pretty under-shrub its specific name; the bracts of *Hortensia* are so coloured and so near the flower, that there are few beginners who do not take them for true petals.

If we are surprised at seeing bracts or sepals taking a petaloid appearance, and if we wished to deduce from it that these organs were not originally foliaceous, we should be quickly undeceived, both by the great number of analogous organs which present the appearance of leaves, and by the examples of leaves which take petaloid colours. Thus, several species, such as *Atriplex hortensis*, are indifferently wholly green, or entirely red; others, such as different species of *Amaranthus*, and especially *A. tricolor*, take under different circumstances, or in different places of the same plant, very decided yellow or red tints; others, such as *Caladium bicolor*, have the centre of the leaf constantly marked with a large rose-coloured spot, as brilliant as the petals. There are some, such as *Tradescantia discolor*, *Begonia discolor*, in which one of the surfaces of the leaf is of the most beautiful red colour; in other cases the leaves are marked here and there with red spots in some species of *Caladium*, with white ones in *Begonia argyrostigma*, and with black ones in *Arum vulgare*. Let us also observe, that towards the end of their life the leaves of a great number of trees take red or yellow tints, which are usually connected with the colour which the fleshy fruits of the same trees take when ripe.

All these examples, which could be easily multiplied, and where we see parts naturally green become coloured, tend to prove that this difference is far from being as essential as might be supposed. If chemists should show that the resinous colouring matter, or the CHROMULE, is not perceptibly different when green (and then

it is called Chlorophylle) or otherwise coloured,* we should easily understand that very slight physiological modifications can cause changes of colour, and consequently that petals were only simple degenerations of foliaceous organs.

What we have said of the leaflets, calyx, and involucrum, may as justly be said of the carpels, for the ovaries are sometimes in a foliaceous state, sometimes coloured, without there being any other essential difference in their organization; thus, very nearly related plants, as *Ornithogalum* and *Scilla*, have the ovary green and of a foliaceous appearance in the one, and coloured and petaloid in the other. There are few families where we do not find the same disparity between analogous genera.

But if the bracts are leaves, which no one has contested; if the sepals are leaves, as can hardly be doubted; if the carpels are leaves, as seems to me to have been demonstrated above; if all these organs, although of foliaceous origin, be however more or less susceptible of being coloured and becoming petaloid; how can the petals themselves be different? Why cannot they be leaves more constantly metamorphosed than the others? This supposition will presently acquire more force when we pursue our researches in the opposite direction, *i. e.* when we have examined if the organs usually petaloid, can present themselves in a foliaceous state.

I may mention, as an example of this, the carpels changed into leaves, which are observed in *Lathyrus latifolius*, in a variety of the Cherry, &c. which I have already mentioned. But these examples may be doubtful, because the carpels, in the ordinary state, are almost

* Since writing the above, this supposition seems verified by the experiments of Macaire, from which it appears to result that the coloured chromule only differs from the green by being more oxygenized.

foliaceous. The examples of petals changed into leaves, though more rare, are more demonstrative. The following are some cases :—

1st. In gardens there is cultivated a monstrosity of the Gilliflower *(Hesperis matronalis)*, the flowers of which are replaced by a multitude of foliaceous organs which are in an intermediate state between petals and leaves, so that we can only consider these flowers as double ones with semifoliaceous petals. Several double varieties of *Anemone*, *Ranunculus*, &c. present this phenomenon; and I have observed flowers of the Fraxinella (*Dictamnus albus*) of which all the floral organs, increased in number as in the preceding case, have taken the appearance of leaves.

2d. Simple flowers also present this phenomenon, although more seldom : I have found in the salt marshes between Dieuze and Moyenvic a monstrosity of *Ranunculus Philonotis*, in which the petals were green, and provided with stomata like leaves, whilst the rest of the flower was in the natural state.

3d. Dumas and Rœper have both found a monstrosity of *Campanula rapunculoides*, which is of great importance in the study of the structure of flowers. This Campanula presents sometimes upon the same plant flowers in the ordinary state, others where the petals are transformed into leaves, and others also where the petals and stamens, and even the carpels, are changed into leaves.

I have observed a very analogous fact in *Anemone nemorosa*. The flowers were disfigured by the transformation into leaves of most of their organs, but the anthers still remaining here and there, clearly showed the primitive character of these organs. M. Bridel has observed a very similar fact in *Erysimum officinale*, where most of the floral parts were transformed into leaves. Cassini

has given a description of *Scabiosa columbaria*, the filaments of which were thick and herbaceous, and the anthers were changed into a small green leaf, of which the filament was the petiole. Therefore all the floral organs are only verticils of leaves in a particular state.

We shall presently revert to this theory and its consequences; let us confine ourselves at present to the observation, that the leaves which surround or form the flower may present themselves in a foliaceous or in a petaloid state, and that, although each of them has a greater tendency to one of the states, it can, notwithstanding, pass into the other from causes unknown to us. These two states seem rather physiological phenomena than truly anatomical differences. The foliaceous state is that in which these organs serve for the nutrition; the petaloid has a more or less energetical tendency to approach the sexual organs. Let us observe in conclusion that the state of verticils, of which the flower, or even the inflorescence is composed, is generally modified in regular succession. Thus, the bracts only become petaloid when the calyces are likewise so; the stamens become foliaceous only when the petals have passed into that state, &c.

Section XVII.

Of the particular Analogy between the Male and Female Organs of Flowers.

The facts contained in the preceding section have already proved that there is a great analogy between the different parts of the flowers; if we pursue this kind of

examination, and observe in particular the sexual transformations, we shall always be more struck with this singular similarity of the organs.

The male parts of plants, or the stamens, may sometimes, from causes unknown to us, be changed into female organs or carpels, and bear ovules instead of pollen. In the cases of this kind which have been observed, the filaments are found in the natural state, and the anthers are transformed into carpels; more frequently the stamens, if numerous, remain partly in the male state, and the inner rows only are changed into female organs. Sometimes we find stamens with the anther half filled with ovules and half with pollen. The first observation of this extraordinary metamorphosis was made by Du Petit-Thouars on *Sempervivum tectorum*, in which this accident appeared frequent, at least in the north of France and in England. My attention having been roused by this beantiful observation, I found a short time after the same metamorphosis in the inner rows of stamens in *Magnolia fuscata*, and I have since frequently seen the male catkins of different species of Willow, where some of the stamens were transformed into carpels, and most frequently the two stamens of the same flower changed into carpels, formed a fruit resembling the ordinary kind. Richard has found a similar transformation in *Erica Tetralix;* Mr. Brown in *Cheiranthus Cheiri;* Du Petit-Thouars and Defrance in the Poppy; Guillemin in *Euphorbia esula;* Seringe in *Cucurbita Pepo;* Rœper in *Campanula Rapunculoides*, &c.

In some of the last examples which I have mentioned, the phenomenon was presented in a particular manner, in being complicated with a case of union. Thus, Mr. Brown remarked that the stamens of *Cheiranthus Cheiri*, changed into carpels, were united together around an

ordinary pistil, in such a manner as to form a kind of sheath, so as to present on a transverse section, besides the two central cells, as many others in an outer row as there were anthers converted into carpels. The same fact was observed by Rœper in *Campanula Rapunculoides*, the fruit of which was found to present two rows of carpels. It is not improbable but the small number of cases where fruits with two rows of seminiferous cells have been described may be phenomena of this class.

Another change, more rare than the preceding, is that where a carpel is changed into a stamen: Rœper has observed it in *Euphorbia palustris* and *Gentiana campestris*. In these cases one of the carpels seemed wanting, and was found under the form of an anther. Not having had an opportunity of seeing this phenomenon myself, I cannot describe it in detail. It is likely that in several diœcious plants we might find that the central stamens of the male flowers are carpels metamorphosed. Perhaps, also, in some flowers which have an inner row of incomplete stamens, and the number of carpels less than in the normal state, it might be found that these incomplete stamens are transformed carpels. We might thus have new means of knowing the organic symmetry of beings.

Section XVIII.

General Conclusions and Considerations upon the Structure of Flowers.

It results from all the preceding Sections, that a flower, considered anatomically, is composed of several verticils

of floral leaves, placed symmetrically one above or within the other, of which some, as the calyx and sometimes the ovary, are of a foliaceous or nutritive nature, and the others, as the petals and stamens, of a petaloid or sexual nature; or, if we consider them in another point of view, of which some serve as protecting organs (calyx, corolla) and the others as sexual organs (stamens, pistil).

Each verticil may be formed of several rows of the same nature, whence it results that the total number of rows may vary from one to several. Thus, we find one in the female flower of *Euphorbia*, and in naked unisexual flowers; two in the male flower of *Euphorbia*, and most unisexual Monochlamydeæ; three in *Cneorum*, and almost all hermaphrodite Monochlamydeæ; four in isostemenous Dicotyledons; five in diplostemenous Dicotyledons and in Monocotyledons considered as being isostemenous; six in Dicotyledons with three rows of stamens, and in diplostemenous Monocotyledons, &c. &c.

On observing flowers in this respect, we see that there exist calyces formed of one or two rows of sepals; we cannot affirm that there are any which have a great number, because of the difficulty of distinguishing with precision the outer rows of the calyx from those of the bracts, properly so called.

There exist corollas with one, two, or more rows of petals.

There are also stamens disposed in one, two, or more rows. It is in the verticil that this number is most variable.

There exist carpels in one row. This is almost universally the case when the rows are numerous; they are then disposed upon an axis which is a prolongation of the pedicil; they are arranged spirally, sometimes provided with special bracts at the base, and thus these flowers approach the structure of capitate ones. This

axis is capable of being prolonged into a branch with leaves, and the same disposition is met with also in flowers where the axis is but little if at all prolonged, provided that the carpels are not arranged in a regular verticil. Thus, flowers with verticillate carpels are true terminations of branches; those with spirally arranged carpels may be terminations of branches, but are so only by the exhaustion of the central parts, and when these are well nourished, or when the sexual parts are abortive, the branch may be prolonged by its apex.

The number of parts in each row of a verticil is fixed in each plant, often in each family: it is most frequently quinary in Dicotyledons, and ternary in Monocotyledons. We may believe that the number of parts in the verticils or rows of the same flower is naturally the same in each; but it appears very different in several cases:—1st, Because the number of rows of verticils is different: thus, frequently there is one row of petals, and two, three, four, &c. of stamens, &c. 2d, Because there is an abortion, union, or metamorphosis of some parts.

The parts of each verticil or of each row are capable of being united together by cohesion in every possible degree, and the degree of union causes what are called the divisions of the parts.

The parts of each row of a verticil or of each uniserial verticil are generally placed alternately with those of the preceding row. When the verticils are multiserial, each row is likewise alternate with the preceding and following one. The verticils and their rows may be unequal, and not resemble each other, without the flower ceasing to be regular; it becomes irregular when one of the parts of a verticil or row is different from others of the same row.

The parts of each verticil are capable of being united by adhesion with those of the neighbouring one; thus,

the petals may be united to the sepals and stamens; the stamens are frequently so to the petals, but very rarely to the carpels. The sepals and carpels may be united by the interposition of the torus, which is the common base of the petals and stamens, which organs then are adherent to the calyx, and appear to arise from near its summit, or from the point where it begins to be free.

The parts of each verticil are capable of being changed into true leaves, like those of the plant. This phenomenon is most frequent in the parts already more foliaceous, as the sepals and petals.

The parts of each verticil are capable of taking a petaloid appearance; this phenomenon is constant in the petal, frequent in the stamens, and more seldom found in the carpels (except in the stylary prolongation), sepals, and bracts.

The parts of each row or verticil are capable of changing to the nature of the row which immediately touches it. Thus, we find the sepals changed to a petaloid nature *(Primula calycanthema)*, petals changed to stamens *(Capsella Bursa pastoris)*, stamens to carpels (*Magnolia fuscata*); or quite the reverse, viz.—carpels changed to stamens (*Euphorbia palustris*), stamens to petals (all double flowers), or petals changed to the nature of the calyx (*Ranunculus abortivus*). Goethe has very happily designated the first of these series of transformations, by the name of ASCENDING or DIRECT METAMORPHOSIS, and the second by that of DESCENDING or INVERSE METAMORPHOSIS.

All the floral verticils then are of a very analogous nature as regards their tissue, but they differ much in their physiological state. Those which are foliaceous, as the bracts and calyx, serve for the nutrition, the others for the sexual reproduction. In several verticils we may distinguish the parts of the leaves which com-

pose them and find more or less clearly the trace of the petiole and limb: the former being developed in the outer organs which serve as the integuments, and the latter in the interior and reproductive organs. Thus, in the calyx, the sepals represent usually dilated petioles, more or less fibrous or foliaceous: sometimes the limb is visible, as in the Rose. In the corolla, the petals appear generally formed by the petiole dilated into a petaloid limb; sometimes they present a claw, which acts the part of a petiole, and a lamina, which acts that of a limb. In the stamens we may also distinguish the filament which represents the petiole, and the anther which is formed of the two margins of the limb rolled upon themselves, thus forming two cells. Lastly, in the carpels it happens most frequently that the petiole is wanting; the limb forms the carpel and the ovules arise from the extremity of the lateral nerves.

The petiole sometimes exists in the carpels (for example, in *Sterculia*, *Phaca*, &c.) and then they are pedicellate; but when there are several carpels with the petioles united, we must take care not to confound this support, which seems an axis (as in *Helleborus*), with the central axis, which is the prolongation of the stem (as in *Myosurus*). I do not know any general rule for distinguishing them. The extremity of the carpels is prolonged into a style, which arises from the point where in a great number of leaves we see a bristle or mucro, or a terminal tendril, which is therefore the rudiment of this organ.

The important differences which are observed between the ordinary or nutritive leaves, and those which compose the flower, are:—

1st. That the ordinary leaves bear a bud in their axil, and rarely have germs developed at the extremity of their nerves (except in *Bryophyllum*); those, on the contrary, which form or surround the flower have no axillary

buds, but, on the contrary, at least when they are formed by the limb and not by the petiole, they have lateral germs capable of being developed into grains of fecundating pollen, or ovules susceptible of fecundation. Perhaps the little bulbs which are developed in the axils of certain floral organs are the representatives of the axillary buds of ordinary leaves, just as the lateral germs of *Bryophyllum* are in ordinary leaves the representatives of the ovules of carpellary leaves. We, however, find examples of floral leaves furnished with buds more or less developed. Rœper has mentioned examples derived from *Euphorbia*, and has shown this fact in *E. Cyparissias*. Choisy has observed, in the Botanic Garden of Geneva, a monstrosity of the Rose, where, in the place of the stamens, upon the inner border of the torus, was developed a verticil of floral buds irregularly formed but capable of being recognised as such; we may add to these facts the proliferous Marigold, Daisy, and Scabious, where the axils of the bracts of the involucrum bear pedicellate floral buds.

2d. Ordinary leaves are almost always opposite or spiral, and those which form the flower are almost always verticillate. Among ordinary leaves there are but very few examples of real verticils (in *Hippuris*, and *Myriophyllum*), for, in most verticils, there are only two opposite leaves which bear buds in their axils, and the others are, consequently, kinds of stipules. In the leaves of the flower there are no examples of spires except in carpels, disposed upon a real axis, and we have seen that this structure indicates perhaps an aggregation of flowers and not a single one; let us also add here that, even when the leaves of the stem are verticillate, the number of each of its verticils has no more connexion with that of the parts of the flower than the number of leaves of each spire can have.

3d. Ordinary leaves, when they are atrophied or coloured, can take the appearance of petals, but they always differ much, and we never see them produce any thing analogous to the sexual organs. The leaves of the flower, on the contrary, are, in their ordinary state, very different from the preceding; but, in certain cases, they completely take their characters, except the existence of axillary buds. Can the position of these organs explain this difference? Is there any means of joining the verticillate position of the leaves of the flower, with the frequently very different one of the ordinary leaves of the same plant? This last point would be of great importance in this,—that it would completely connect the history of the reproductive organs with that of the organs of vegetation; but the efforts made to attain this object are as yet too hypothetical and incomplete to be mentioned.

A curious example tends to confirm the extreme analogy of the leaves with the floral parts. There is cultivated in gardens a monstrosity of the White Lily, in which, in the place of the flowers, the extremity of each branch bears an indefinite number of leaves disposed spirally, or imbricated as the ordinary ones, but which are distinguished because they are coloured, and entirely petaloid; they differ then from the parts of the flower only in not being verticillate.

From all the examples and the analogies which I have pointed out, we may conclude, as the illustrious poet Goethe maintained; as several botanists of the German school, and especially Rœper, have admitted; as Turpin has partly developed in his Iconographie; as Mr. Robert Brown appears to admit in different passages scattered throughout his works; as I have myself partially indicated in several of mine; we may, I say, conclude that the leaves, or appendicular organs of the stem, modified

by their position, compose all the parts of flowers. A flower, then, is a kind of rosette, or terminal bud, the leaves of which are verticillate, and take a less degree of nutritive development than ordinarily, but acquire, in return, new forms and functions. When the force of vegetation is very great, a larger number of leaves take a foliaceous state, and the branches bear fewer flowers; when the vegetative force is diminished, the upper leaves have a greater tendency to be transformed into floral parts: this is a law to be observed, practically, by gardeners.

The extreme ease with which, by this theory, we can explain all the anomalies and monstrosities of flowers, i a sure pledge of its truth. Astronomers only regarded their science as well proved, when they were able to explain by its means the apparent aberrations of the stars.

We may say, in a very widely extended sense, that there only exists three organs in plants—the root, the stem, and the leaves, and that the different modifications, which the summits of the stems and the appendicular or foliaceous organs present, constitute all the apparatus of the flowers and fruit.

But because the floral parts may be considered as modified leaves, we can by no means conclude that, in changing form, they cannot take new functions; and it seems to me, we ought not to attach to this idea any argument against the theory of the sexes. Every analogy tends to prove, on the contrary, that the modified organs often serve very different purposes from their primitive ones, and in particular the sexual fecundation appears to me to be demonstrated in plants, almost to the same degree as in animals.

CHAPTER III.

OF THE STRUCTURE OF THE FRUIT OF PHANEROGAMOUS PLANTS.

Section I.

Of the Fruit in general.

When fecundation has taken place, the organs which were destined to effect it, perish with more or less rapidity; the stamens wither and fall off, in the greatest number of cases; the petals follow the same fate; all the sexual portion of the carpels undergoes the same change; the stigma and style wither and usually fall off; the pistillary cord, or the fibres which go from the style to the ovules, wither likewise,—they disappear either by an evident destruction in the small number of cases where, as in *Lychnis dioica*, they are free from all adhesion, and, consequently, visible, or by simple obliteration in the cases, by far the most numerous, where they are imbedded in the tissue of the carpels.

Whilst the truly sexual organs disappear after they have fulfilled their office, the fecundated ovules have taken a life of their own; they attract the nourishing juices, and are developed with their immediate covering —the foliaceous part of the carpels. The name of Fruit *(fructus)* is given to the body which results from the ovules transformed into seeds, by the fecundation of the

carpels which surround, contain, and nourish them, and from all the parts of the flower which, adhering to the carpels, seem more or less to form an integrant part of all this apparatus. The fecundated ovules bear the name of SEEDS *(semina)*, and their envelopes have collectively received that of PERICARP *(pericarpium)*, a term which is not exactly applicable to an organ which is not around the fruit, but forms an integrant part of it.

The study of the fruit, considered collectively, bears the name of CARPOLOGY.

It is to Gœrtner that we owe the first exact descriptions of the fruits and seeds of plants, and Bernard and A. L. de Jussieu were the first to make us understand the importance of the carpological characters in the classification of plants; since then several distinguished botanists have directed their attention to Carpology.

Two causes, however, have principally contributed to render the study of the pericarp more difficult and confused than it ought to be, viz.—1st, that for a long time it was only studied when it had attained maturity, and, consequently, the true character of the parts of which it was composed could not be judged of, seeing that several of them are obliterated or developed, or united together during maturation; 2d, that it, as well as most of the floral organs, has been considered as a single organ divisible into distinct parts, whilst it is always more true and advantageous to consider first the elementary organs themselves, and afterwards the results of their different aggregations. We do not say then, with a modern botanist (Mirbel), "that the flower never has more than one ovary, and that the little distinct bodies, fixed upon the same receptacle, are only portions of a single pericarp;" but we affirm, on the contrary, that the flower usually has several carpels, which are sometimes separate, sometimes united into a single body. In order to

avoid these causes of doubt, after having examined the pericarp, as we have already done, in the state of an ovary, and in its connexions with the floral parts, properly so called, let us consider here, in their isolated and simple state, the elementary parts of which the pericarp is composed, and afterwards let us examine the consequence of their union, first with each other, and then with the neighbouring organs.

I suppose throughout all the following description of the pericarp, that all that I have said in the preceding chapter upon the flower, and particularly upon the pistil, is recollected. I beg those who would read the chapter upon the fruit, not to do so until they have read the preceding one.

Section II.

Of the Carpels considered in the state of separation from one another.

The Carpels, as we have said in speaking of the pistil, are the female organs of plants, most frequently verticillate in the centre of the flower, and which, sometimes free, sometimes united, form the pistil during flowering, and afterwards the fruit.

Each carpel may be considered as a leaf folded longitudinally upon itself; if we examine its texture, we shall find that, like the leaf, it is composed of three parts, which really constitute a single envelope, viz.—

1st. Its external surface, which represents the lower face of the leaf, is a kind of cuticle separable in a great number of fruits, such as the Peach, and existing in all. Richard has given it the name of Epicarp *(epicar-*

pium); like the lower surface of the leaf, it frequently bears hairs, glands, and stomata, and presents in most cases a decided analogy to the part of the leaf to which it corresponds.

2d. The inner surface, which represents the upper part of the leaf, is a membrane to which Richard has given the name of ENDOCARP *(Endocarpium);* its internal position, preventing its exposure to the air and light, causes it to differ more than the epicarp from the corresponding part of the leaf. Sometimes it appears under the form of a fine membrane, foliaceous and even greenish, as in the Pea; sometimes under that of a fine, pale, and as it were, etiolated membrane, as in *Asclepias;* this membrane sometimes becomes thicker, and sometimes even hard and bony, as in the Peach, and then it forms the stone of the carpel. All the intermediate states between those which I have mentioned are found in various fruits.

3d. Between the Epicarp and Endocarp is found the plexus of fibres, vessels, and cellular tissue, which constitutes the body of the leaf or carpel, representing the mesophyllum of the former; it has received the name of MESOCARP (*mesocarpium).* Sometimes it is very thick and fleshy, as in the Peach, or Cherry, and then the name of SARCOCARP, or more commonly, that of the FLESH *(caro)* of the fruit is given to it. Sometimes it is thick, but dry and fibrous, and then it is called the HUSK, as in the Almond. Sometimes it happens that the epicarp and endocarp separate during their growth, and leave between them an empty space, in which are still observed traces of the fibres of the mesocarp; this rare and singular organization is seen well in *Cysticapnos Africana.* Sometimes it is also distinct, but less thick and more foliaceous, as in the Bean and Pea; at times it is so thin, that it cannot be easily distinguished

from the epicarp and endocarp; but however thin it may be, we are always compelled to admit its existence, since it is only by this plexus of vessels that the organ is nourished.

In the same manner as we have seen, in speaking of leaves, that the more stomata there are, the thinner will this plexus be; so, among carpels we shall find three particular states of the mesocarp connected with the structure of the epicarp. Thus, sometimes the carpellary leaf is membranous, and almost scarious, and then the epicarp has no stomata, and the endocarp little or no flesh, as in *Amaranthus;* sometimes the epicarp has stomata, and the endocarp has the ordinary foliaceous texture, as in the Pea; sometimes the epicarp has no stomata, and the endocarp becomes thick and fleshy, as in succulent leaves; this is what we see in the Peach and other fleshy fruits.

Fruits compared together when ripe, present different kinds of adhesion or separation of the mesocarp; thus it adheres sometimes very strongly to the endocarp, as in the Nectarine, or Bean; at other times it easily separates, as in the Peach, or husk of the Walnut, or in *Entada,* in which it is detached naturally or easily, remaining free from the epicarp. The adhesion of the mesocarp with the epicarp is equally variable; thus the latter is easily detached in the Peach, with difficulty in the Cherry.

The leaves which form the carpels are presented under several different systems; thus, they may be:—

1st. Curved in the form of a cylinder, tapering to the two extremities, having the two margins beveled off upon one another, and the back round, as in *Colchicum, Delphinium, Sterculia,* &c.

2d. Curved in the form of a horn, so that the margins approach each other at the base, and the upper part remains open, as in *Astrocarpus, Helleborus, Isopyrum,* &c.

3d. Folded upon their middle nerve, so that the margins are applied to each other, forming a longitudinal line, as in the Pea, Bean, &c.

4th. As the leaves are curved or folded, their two seminiferous margins may be more or less folded inwards, so as to divide the carpel by semi-partitions, or by longitudinal ones, as in *Astragalus*.

5th. The dorsal nerve of the carpel or the middle one of the leaf, may be so pushed inwards, as to form a projection which also tends to divide the carpel into two longitudinal cells, as in *Oxytropis*.

These different modes of folding or curving of the leaf, correspond, as it is easy to ascertain, with the modes already described, of the rolling or folding of the leaves in the bud. When the carpels are formed of a leaf, folded lengthways upon itself, the two lateral surfaces may be either flat, as in *Spartium Junceum*, or more or less convex, as in the Bean, or *Crotolaria*, or folded at a more or less obtuse angle, a combination which in general takes place only by the pressure of neighbouring organs.

The line formed by the approximation of the two margins of the leaf, and which represents a suture, is called the SEMINIFEROUS SUTURE, because it is upon its inner edge that the seeds are usually attached, or the VENTRAL SUTURE, because it is opposite the back of the carpel.

When the carpel is formed of a leaf curved longitudinally, it only presents this suture, and receives then the particular name of FOLLICLE, *(folliculus.)* It is called a COCCA when the suture opens with elasticity.

When the carpel is formed by a leaf folded upon its middle nerve, it frequently happens that, at maturity, the dehiscence takes place along this nerve, which has for this reason received the name of the DORSAL

Suture; and this is given to it by analogy, even when it does not open, provided that the nerve be well-marked: but it must be remarked that this suture is the rupture of an organ by a natural dehiscence, whilst the first is disunion of two portions cohering together; the carpels formed by leaves folded lengthways having consequently two sutures, bear the generic name of Legume, *(legumen)*. There are some families, such as the Ranunculaceæ, where the existence of the dorsal suture is so slightly perceptible, that we see in neighbouring genera carpels which may be referred, almost at will, to follicles or legumes.

When the carpels are long, with their valves flat, or nearly so, and their seeds situated at small distances, two phenomena frequently happen, which modify their ordinary state. Sometimes the portions of the carpel which are found between the seeds, are united together by a kind of natural union, or by a development of the cellular tissue, which forms kinds of false partitions between the seeds: this constitutes the legumes which are said to be multilocular, or to have transverse cells, as, for example, in *Clitoria*. At other times, the portion of the carpel situated between the seeds is developed less than that which is around them, and then the legume presents here and there swellings and contractions. These different states of legumes with transverse cells or joints are expressed collectively, by calling them Lomentaceous carpels or legumes. Sometimes the two phenomena occur at once, as in *Sophora*.

The carpels sometimes have a thecaphore or support, which is to the carpellary leaf what the petiole is to the ordinary one. This Thecaphore is very visible in *Phaca*, *Glottidium*, *Colutea*, and several other Leguminosæ. It must be observed that this pedicel of the fruit is often spirally twisted, whence it results that the

carpel is then presented in a position contrary to the natural one; the seminiferous suture is found situated externally, and the dorsal internally.

The point whence the style takes its origin, whatever be its position, is considered as the anatomical apex of the carpellary ovary. In the greatest number of cases, it is situated at the apparent apex of the fruit; thus, for example, in the Pea or Larkspur, the style proceeds from the tip of the ovary; but there are plants where the ventral suture is very short and the dorsal very much swollen out, whence results a lateral position of the anatomical apex, for example in the genera *Rubus, Fragaria, Potentilla*, &c.

The style most frequently dries up or falls off after fecundation; but sometimes the whole of it, or at least its base remains, either without changing its form, or becoming elongated, or hardening so as to form at the top of the ovary a more or less decided point: for example, in *Dryas* and *Clematis* it forms a long bearded process; in several species of *Geum*, one without a beard; in *Trigonella* and some species of *Ranunculus*, a nearly spiny process, &c. Sometimes the two placentary styles are separate, and then result ovaries terminated by two points or bifid carpellary styles, as, for example, in certain kinds of *Euphorbia*.

There are great differences between the carpels, resulting from what takes place in them at maturity. Some do not open naturally, and are said to be INDEHISCENT; the others, which are called DEHISCENT, open in various ways.

Indehiscent carpels are of two kinds:—

1st. Those of a dry, scarious, bony or membranous nature, have very little juice, few or no stomata, and only contain two ovules, one of which is abortive, most frequently before maturity. In these carpels the seed is

often united to the pericarp, or this organ is so well moulded upon it without adhering, that the two bodies seem confounded; it is this which has caused the term, Naked Seeds, to be applied to them, a very incorrect one, which might be replaced by that of Pseudospermous fruit or carpels; the sutures, even the ventral one, are here scarcely perceptible, being often reduced to a simple nerve or fold, sometimes hardly visible. At maturity these carpels, detached from the peduncle, are sown without opening; the seed, which is within, germinates without coming out, and, as it is usually solitary, this is performed without difficulty. It is to this class of fruits that the following belong, viz.—

The Utricle *(utriculus)*, where the carpel is membranous and does not adhere to the seed; as in *Amaranthus.*

The Nut *(nux)*, where the carpel is osseous or stony, and does not adhere to the seed, as in the Cashew-nut.

The Caryopsis, where the carpel adheres intimately to the seed, as in Wheat.

2d. There are other indehiscent carpels, which have the mesocarp more or less developed and fleshy. In plants with carpels solitary by abortion, or isolated from one another, we only find them fleshy in those which have naturally one or two seeds. Some are of a fleshy nature, with the endocarp membranous; such are, for example, the little round carpels, which, by being collected on a common axis, form the fruit of the Bramble and Raspberry: others have the mesocarp fleshy, with the endocarp bony; to these the name of Drupe (*drupa*) is given; such are the fruit of *Detarium* and *Geoffræa* among the Leguminosæ; Plums, Cherries, and Peaches among the Amygdalaceæ: finally, there are others which have the mesocarp fibrous and the endocarp bony, as the fruit of the Almond. It must be observed,

that in these two last classes, the endocarp retains the original form peculiar to legumes; for whilst the epicarp and mesocarp are perfectly continuous and indehiscent, the stone presents two sutures and two valves like legumes, and has a tendency to open, at least at the period of germination, or sometimes sooner. In all fleshy carpels, the epicarp and mesocarp are destroyed by putrefaction or maceration; and the seed, invested with the bony or membranous endocarp, is sown and germinates as in pseudo-spermous fruits.

We must not confound with the flesh, which is a watery or fleshy development of the mesocarp, the PULP (*pulpa*) of the fruit; this is only found in the interior of the carpel: thus, for example, the legume of *Cassia fistula* is dry and encloses a true pulp: this pulp is not an organ, properly so called, but is a secretion of the endocarp, placenta, umbilical cord, or of the surface of the seed. It is probable, that we confound under this name, various matters secreted by different organs; thus, I am inclined to believe that the sour and acid pulp of *Sophora* proceeds from an organ different from that from which the sweet and laxative pulp of *Cassia*, &c. does.

Dehiscent carpels may open in different manners. The most simple case is that where the two margins of the carpellary leaf separate at the point of union and open lengthways, as in follicles. Sometimes this dehiscence takes place throughout the whole length, as in *Asclepias;* sometimes only at the top, as in *Trollius.*

A second very frequent case is that where the dehiscence takes place by the ventral suture and by the dorsal nerve or suture, as in the legumes of most of the Leguminosæ.

But it sometimes happens that the two sutures so cohere together, that they cannot open. Thus, if the

legume contain several seeds, the dehiscence takes place in one of the two following ways:—when the fruit is unilocular, each of the valves splits lengthways along the middle, forming two longitudinal ruptures; this takes place in the legume of *Hæmatoxylon:* or when the fruit is divided into transverse cells, as I have above explained, a rupture is made transversely along the partition or contraction which separates the cells, and each of them (which then take the name of Joints) is found separated from the others, and transformed, as it were, into a pseudo-spermous fruit, which does not open, but is sown with the seed enclosed. And here also are presented two cases: sometimes, as in the Hedysareæ, each joint carries with it the two sutures perfectly entire; sometimes, as in several Mimoseæ, the sutures remain, and the cells open at the same time that they separate from one another.

In all these cases, it evidently results from the dehiscence that the seeds, when they are numerous in the same carpel, are permitted to be dispersed so as to be sown separately.

We have already said that the seeds are attached either to the inner margin of the carpellary leaf, and, consequently, along the ventral suture, or at the base or apex of the carpel, but always laterally, and in reality near the top or bottom of the ventral suture. These three positions, then, differ only in this, that in the first case they arise all along the suture, in the second only at its base, in the third only at the apex. In every case, the portion of the carpellary leaf from which the seeds arise, has received the name of Placenta.

The placenta is usually a kind of thick ridge, composed of spongy cellular tissue, and pierced by two sets of fibres: the first, which proceeds from the peduncle, conducts the nourishing fluids; the other, which comes

from the style, has borne the fecundating liquor to the ovules, and has generally disappeared when the fruit is formed. These two orders of vessels are subdivided into as many filaments as there are ovules, and a filament of each kind penetrates the seed, which is connected with the placenta by a cord of variable form and length, called the Umbilical Cord, Funiculus, or Podosperm ; this cord, at the time of flowering, was composed of one filament coming from the pistillary cord, and of another from the nourishing one; the first usually disappears very soon after fecundation. There are very rare cases where the two filaments, the combination of which composes the ordinary funiculus, are found completely distinct: thus, in *Statice*, the nourishing filament proceeds from the base of the ovary, the fecundating one from its summit, and they both reach the seed distinct.

The placenta is but little evident at the period of flowering; it afterwards enlarges and becomes full of juice, which the seed absorbs during its growth ; whence it results, that at maturity, the placenta is dry and flaccid, resembling old pith. The larger it is in proportion to the seeds, the more does it serve to nourish them: thus, it is remarked that when fruits have a large placenta, as in *Cobæa*, we may cut them long before they are ripe, without endangering the maturation of the seeds, which absorb from this resorvoir the juices which are necessary for them ; whilst in pericarps where it is small, the seeds cannot ripen after the fruit is detached from the plant. When the placentæ are dry, it sometimes happens that, at maturity, they naturally separate from the carpellary leaf from which they originated.

When the placentæ are placed along the ventral suture, they are very evidently double; it is the same

also when they are reduced so as to occupy only the base or apex; for these are still the same two organs, but much shorter than ordinarily. Since the placentæ of a carpel are necessarily double, and each of them has, in the regular state, an equal right to bear seeds, it results:—1st, that the natural number of seeds in a carpel ought to be always even when there is no abortion; but they are rarely placed exactly at an equal height along each suture; on the contrary, they are situated alternately: this disposition is very evident in legumes and long follicles; but when the carpel is so short as only to present one ovule on each placenta, there are presented some cases which deserve notice:—

1st. The two ovules may arise, as in long carpels, one above the other, at so great a distance that both arrive at maturity: this is what happens in the legumes of the dispermous Leguminosæ, and then the two seeds are clearly horizontal.

2d. These two alternate ovules are sometimes so close, that one of them becomes abortive, the other only arriving at maturity; in this case, it happens either that it is the upper one which is abortive, and then the lower one finding more space towards the higher part of the carpel, takes an erect position, or it is the lower one which is abortive, and then the superior one finding more space towards the base of the carpel, takes a pendent position. It is very probable that it is to this double cause that we must refer the diversity of direction of the seed of the monospermous Ranunculaceæ, which are either ascending or pendent, whilst those of the polyspermous ones are horizontal; if one were to find a Ranunculus or Clematis, the carpel of which presented the two ovules arrived at maturity, they would be either horizontal, or one ascending and the other pendent.

3d. The two ovules may be very near together either

at the base or apex of the fruit; in this case one is very frequently abortive, and in this manner the monospermous carpels of the Compositæ and Dipsaceæ are formed. But when we find, now and then, one of the Compositæ with the fruit having two ovules, we see that they are both ascending, and it is very likely that, if we should find two in the Dipsaceæ, they would be both pendent.

Whenever a carpel contains several seeds, they are free and not united to the inner surface of it; but when it only contains a single seed, this one is sometimes free, as in the utricles of the Amaranthaceæ, or united by its entire surface with the carpellary leaf, as in the fruit of the Gramineæ; and then the carpel is so confounded with the proper integument of the seed, that it does not seem to exist; it is in this case that seeds were called naked, but there are none really devoid of the pericarp. In fact, the style necessarily takes its origin from the pericarp and not from the seed, and consequently, every organ from which we see, at the period of flowering, a style or stigma arise, is a true pericarp, whatever be its appearance.

Seeds may appear naked from three causes:—either by the intimate union of the seed with the carpel, as in the Gramineæ:—or because, as in certain species of *Leontice*, or in *Slateria*, the seed, growing rapidly, breaks the carpellary leaf and is found exposed:—or because, as in *Reseda*, the carpellary leaves not being completely folded upon themselves, leave their extremity open, and consequently the seeds naked. But we know that neither of these causes answers exactly to what was intended by the term of naked seeds, and that the pericarp exists or always has existed.

The manner in which the seeds of a carpel ripen and are dispersed, accords with the principles above declared. In all carpels with a long placenta, *i. e.* when the seeds

are situated all along the ventral suture, the seeds receive the fecundating matter by the branches of the pistillary cord, which terminate there; those at the top receive it before the others, and their vital action immediately commences; consequently, they ought to ripen first: we see this in all polyspermous legumes and follicles; and as it is also at the top that the dehiscence of the sutures commences, it follows that the seeds fall out according as they ripen.

As soon as the seeds have fallen out, or a little after, the VALVES of the legumes (this name is given to the two portions of the carpellary leaf separated by the dehiscence of the sutures), the valves, I say, twist, either rolling up towards the outside or spirally upon themselves, or by irregular torsions; they sometimes retain, on separating, their primitive position.

The carpels frequently bear foliaceous or spiny tufts, or tubercles, sometimes upon both margins of the suture, sometimes upon their sides or valves; these peculiarities, which are sometimes of interest in order to know such or such a fruit, are generally of but slight importance in Carpology.

All that we have said in this section is applicable—

1st. To carpels which are naturally isolated from each other in the same flower, and which constitute what is called a COMPOUND fruit: such are the two follicles of the Apocyneæ, the verticillate carpels of *Alisma* and *Delphinium*, the carpels collected into a head or spike in *Ranunculus*. On combining what is contained in this Section and in the preceding Chapter, it seems to me that we have their complete history presented to us.

2d. To carpels, which, originally resembling the preceding, have become solitary by the abortion of those which ought, in the normal plan of the flower, to form a complete verticil, as the solitary legume of most of the

Leguminosæ, the solitary carpels of the Larkspur. This solitariness of the carpel, produced by the abortion of the neighbouring ones, is perceived by the lateral position of the seeds; this has caused them to be confounded with fruits formed by the natural union of several carpels. To these has been given, very improperly, and solely on account of their external appearance, the name of SIMPLE fruits, although they are more complicated, and this name is much more applicable to those of which we are about to treat. Let us now examine the results of the natural union of the carpels of the same flower.

SECTION III.

Of the Carpels of the same Flower united together.

The carpels proceeding from the same flower may be united together at two different periods:—

1st. There are some which are originally perfectly free and distinct, but so near to each other, that, if they become fleshy, they can unite together, on approaching maturity, into a single body usually slightly irregular. This late union of numerous and fleshy carpels is very well seen in *Dillenia* and *Anona;* there results from this aggregation a fruit marked with areolæ, which are the traces of the tops of the carpels; the seeds appear irregularly distributed in the mass, because the walls of the carpel being fleshy and united, we cannot recognise their primitive disposition.

2d. In a great number of flowers the carpels are naturally united together from the first; this circum-

stance so modifies their form and appearance, that it is necessary to describe it in detail. That fruits with several cells placed horizontally are composed of carpels united together, is what, I think, cannot appear doubtful to any one who has attentively studied the article upon the Pistil in the preceding Chapter. Some examples seem to render this fact more particularly evident; thus, among the Helleboreæ, we find some with the carpels perfectly free, such as *Aconitum*, whilst in certain genera, as *Nigella*, we find species where the carpels are united at the base only, as *N. orientalis:* others, where the union proceeds half-way, as *N. sativa*, and others where they are united nearly to the apex, as in *N. Damascæna*. It is the same in the Apocyneæ and Asclepiadeæ, in which we find all the gradations, from the perfectly free carpels of *Asclepias*, to those of *Cerbera*, *Rauwolfia*, &c. which are united into an apparently simple fruit. Similar examples are found in a great number of families.

We have already found, in these facts, a very simple explanation of what was, or ought to be meant in speaking of entire, divided, parted, and compound fruits. Entire ones are those where the carpels are united throughout their whole length; divided ones, where the union only proceeds half-way; parted ones are those where the carpels are only united at the base; compound ones, where the carpels are free from all cohesion.

In fruits with the carpels united throughout their whole length, there may also be several cases: the carpels either have the ventral suture prolonged more in proportion than the dorsal, and then the whole fruit is more or less pointed at the base, or *vice versâ*, and then the fruit is necessarily lobed at the summit: or, lastly, the two sutures are perceptibly equal, and then the fruit is obtuse or truncated. Thus, all the longitudinal

divisions observed in fruits are easily understood to result from the union of the carpels.

When the carpels are verticillate, their approaching a central axis (which is called the Columella when it is real, and the Axis properly so called, if it be ideal,) causes them to take a triangular form; their union takes place by the two sides sloping inwards, and the dorsal face of all the carpels forms the external part of the fruit, which results from their union. When this dorsal face is uniformly convex, the fruit is round, as in *Rhizophora;* elliptical, as in the Coffee; or globular as in the Grape, the Elder, &c. When the dorsal face is more convex than the fruit taken collectively, the fruit then presents as many furrows as there are sutures, or points of union of the carpels, and as many round projecting sides as there are convex carpels, as for example, in the Melon, *Ricinus*, &c. If the back of the carpel be angular, or if the carpel be, as it were, folded upon the middle nerve, the fruit then presents as many angular sides as there are carpels; the retreating angles indicate the sutures, and the projecting ones the backs of the carpels, as in *Hibiscus esculentus*, *Oxalis*, &c.; these projecting angles are sometimes even prolonged into wings, as in *Dodonæa*. Thus all the lateral depressions or eminences which are observed on the surfaces of fruits, are also easily understood in the theory of the union of the carpels, and depend upon their elementary forms. These forms are sometimes obscured by the unusual development of the fleshy part of the mesocarp.

The most usual structure of the carpels is when their two retreating faces reach into the interior of the fruit, as far as the axis, and then the fruit presents as many Cells *(loculi)* as there are carpels entering into its formation; we then say that it is Multilocular, or Bi-, Tri-, Quadri-, Quinque- &c. locular, when we

wish to designate the number. These cells are separated by vertical PARTITIONS *(septa)*, formed by the more or less intimate union of the retreating faces of the two contiguous carpels. These retreating faces appear composed only of the endocarp and a very thin expansion of the mesocarp; as for the epicarp, it is not prolonged, or at least it is not visible upon the partitions. The seeds are then placed at the central angle of each cell, attached to the extremity of the retreating face of the carpel, and consequently, (except in cases of abortion,) to the number of two at least in each cell, or always in equal numbers. All that I have said above of their position in isolated carpels, is applicable to the cells of fruits with cohering ones.

When the carpels of which the fruit is composed are lomentaceous, or divided by diaphragms, as transverse partitions, then each principal cell is subdivided by these cellular diaphragms into smaller ones situated one above the other; we see this in *Amaioua* among the Rubiaceæ, in the lomentaceous Cruciferæ, &c.

We reserve the name of FALSE CELLS, or of CAVITIES, for certain spaces which are found in some fruits, and which do not contain seeds, not from abortion, but from their peculiar nature. The most remarkable example of these cavities is observed in *Nigella Damascæna,* so common in gardens; its fruit, cut transversely, seems to have ten cells, of which the five inner ones which contain the seeds at the internal angle, are the true cells, and the five outer ones, devoid of seeds, are the cavities; these result from the epicarp swelling up during maturation, so as to break the mesocarp, and form in its place a space or air-cavity. In several fruits we find cavities more or less decided, either in the axis of the fruit, when the carpels, instead of reaching the centre, leave there a small empty space; or between the cells,

when the retreating faces of the carpels are not intimately united together; or on the sides of the valves when they are puffed up, as in *Myagrum;* or at the top of the pedicel, or in the axis, when it is fistular; or, lastly, at the base of the style, when this base is, in like manner, fistular. These last cavities are remarkable for sometimes containing a seed, as is seen in *Brassica cheiranthos,* and in *Trianthema monogyna;* this kind of seminiferous cavity or stylary cell is of rare occurrence, and inexplicable by any carpological theory; its detailed observation merits the attention of anatomists.

We have seen how the cells are formed in fruits by the folding back of the margins of the carpels as far as the axis; let us now examine what happens when the retreating parts do not reach the centre. Three cases are here presented to us: they either extend half-way in from the top to the bottom, or they are so short as to seem absent, or they nearly reach to the centre at the base of the fruits, but are absent at the upper part.

When the retreating parts of the carpels are prolonged into the interior without reaching to the axis, there results a fruit, the centre of which is empty and the circumference presents as many cells, open on the inside, as there are carpels; these cells bear the name of SEMI-CELLS. The partitions, which are then called SEMI-PARTITIONS, bear the seeds on their inner margins, as usual; this is seen in certain Poppies and Hypericineæ: on comparing together the species of these two groups, we meet with almost every degree, from partitions which reach very nearly to the centre, to those which are so short as hardly to have their edges visible.

When the partitions are so short as to be hardly visible, the placentæ are then, as it were, applied to the sides of the fruit, and each carpel is reduced to its dorsal face. The fruit is then said to be UNILOCULAR,

multilocular

and the seeds are Parietal; we see this in *Viola*, *Helianthemum*, *Passiflora*, *Reseda*, *Argemone*, the Capparidæ, &c.

Lastly, if the retreating parts only bear the seeds at their base, and as it is this portion which is extended towards the centre, the seeds are found placed at the centre of the base of the fruit, and then the two following cases may happen:—

1st. Sometimes the partitions are prolonged towards the centre as far as the top, and then, not bearing seeds, they are usually thin and membranous; in this case, the fruit has still several cells with the seeds at the bottom of each, as in some multilocular Caryophylleæ.

2d. Sometimes the upper part of the partitions appears to be wanting at maturity, because the carpels, which, at the period of fecundation, were of the same length as the placenta, afterwards elongated so as to rupture the upper part of the partitions, and, more or less, completely isolate the placenta. This appears to take place in several Caryophylleæ. In all these cases, the fruits are said to be Unilocular, and the seeds attached to a Central placenta, although in reality the fruit is always formed of united carpels, the retreating parts of which bear the placentæ on the inner margins.

We have above seen, that each carpellary placenta is prolonged into a style, that the union of the two placentary styles forms the carpellary one, and that the union of the carpellary ones forms the style properly so called. This organization never presents any difficulty when the placentæ occupy the whole length of the fruit; thus, whether the placentæ reach the centre, whether they stop half-way, or whether they hardly exceed the margin, we know that they have a direct communication with the style. But what takes place when the placenta is central, and does not reach the apex of the fruit?

There may happen two cases which correspond to those mentioned above.

Sometimes the partitions may originally be in a state of great tenuity, or the carpels, at the time of flowering, may not be longer than the placentæ, and then the filament which proceeds from the placenta can reach the base of the style and transmit the fecundating matter to the ovules. This filament is destroyed after fecundation, either by the destruction of the partitions, or by the elongation of the carpels; and then at maturity we do not find it, and can only conceive how the fecundation could take place by having recourse to the anatomy of the ovary at the period of flowering. We see this in all the Caryophylleæ with a central placenta; sometimes the filaments, which at the time of fecundation arise from the placenta, are distinct, as in *Lychnis dioica*, where there are five; in *Stellaria*, where we see three (Pl. 20, fig. 1); sometimes they are all united into one, as in *Arenaria* (Pl. 20, fig. 3, 4). An analogous organization is met with in the Portulaceæ (Pl. 20, fig. 7, 8), where we find three distinct filaments; in *Primula*, where the placentæ are all united into a nearly globular body, the filaments also being united into a point which reaches the base of the style. In all these examples, the filaments are wholly or in part destroyed after fecundation, and the placenta seems isolated from the style.

It may also happen that the branch of this pistillary cord may go along the margin of the carpel which does not retreat, as in fruits with parietal placentæ, and thus it arrives at the base of the fruit and to the seeds which are there situated. It is this, probably, that takes place in the fruit of *Luzula*, for example, where we find the seeds attached to the base of the valve.

The placenta is usually placed at the inner angle of the more or less retreating part of the carpel, either

throughout its whole length, or only at the base; but its form and dimensions present some remarkable differences, which modify the structure of the fruit. Most frequently, it presents an elongated ridge bearing one or two rows of seeds; sometimes becoming very large and thick, it extends into the interior of the cell, forming a large projection, as is seen in *Datura, Solanum, Nicotiana*, &c.; sometimes it spreads out and lines the whole of the retreating part of the carpel, as is seen in the Poppy and *Nymphæa;* and at other times, it is expanded into a kind of net-work, applied to all the inner walls of the carpel, and bearing here and there the seeds, as is seen in the Flacourtianeæ and Butomeæ.

The Cruciferæ present, in this respect, an organization which is peculiar to them; the two carpels, which compose the SILIQUA (this is the name given to this kind of fruit), have their retreating margins reduced to an extremely thin and delicate membrane, which may be regarded as an internal prolongation of the epicarp alone, and the placentæ are situated upon the margins of the endocarp, which is not prolonged into the interior, so that the seeds are parietal, although the fruit is bilocular.

All these various combinations are often rendered obscure in fruits which open at maturity, by the different modes of dehiscence; and in indehiscent fruits by the development of the pulp or flesh, which confounds their different parts in an almost indistinct mass: these two causes of obscurity, as well as those which proceed from abortions or from the state of the central axis, deserve to be analyzed.

All the modes of dehiscence which we have found in isolated carpels, may be met with in cohering ones, but modified and multiplied by this cohesion.

The most simple, but not most frequent case is that which is called SEPTICIDAL dehiscence, because it takes place in the partitions which seem to split in two: there is a particular case of this, which I name DEHISCENCE BY SEPARATION; it consists in the carpels being so slightly joined together, that they separate from one another at maturity, forming so many distinct bodies, at first closed, afterwards opening, by one of the systems mentioned above, in solitary carpels; thus, the carpels of the Colchicaceæ separate at maturity, and open in the manner of follicles by a fissure along the ventral suture, which in the entire fruit was central. Thus the carpels of *Hermannia lævigata* separate at maturity, and each of them opens by its two sutures, as most legumes.

This dehiscence is also modified by the existence or non-existence of a central axis: when this does not exist, it may happen, either,—1st, that the carpels detach themselves entirely from one another, leaving the centre of the fruit void, as we see in *Colchicum;* or, 2d, that the extreme portions of the partitions, which bear the placentæ, may be so united together as not to separate, then the rupture takes place along the placenta; the carpels open by leaving in the centre a false seminiferous axis, formed by the intimate union of the inner margins and placentæ; this takes place in the Balsam. When the axis exists, the same two cases may happen: sometimes the carpels, on detaching, carry with them the placentæ, and leave the axis bare, as in the Malvaceæ, Euphorbiaceæ, &c. Sometimes the placentæ may remain united to the axis, and the rupture may take place along the partitions; but I do not know an example of this mode of dehiscence, and, in general, it is not always easy to distinguish the case where the apparent axis is formed by the placentæ alone, or by the placentæ united to the axis.

Let us suppose, now (and of this there are numberless examples), that the two retreating faces of the carpels are so united together that they cannot separate, and that, notwithstanding, the fruit must open, and this always happens when, if not fleshy, it is filled with seeds. There takes place then a DEHISCENCE BY RUPTURE, and this may be presented under six different forms, viz.:—

1st. (And this is the most frequent case), the dehiscence takes place along the dorsal nerve, or middle line at the back of the carpel; this is what we call LOCULICIDAL dehiscence, because it occurs in the middle of the cells; in this case, one is always inclined, at first sight (and I myself, with most botanists, have for a long time committed this error), to take for the primitive elements of the fruit, not the carpels properly so called, but the MEDIASTINS, that is to say, the bodies formed by the halves of two carpels united together by their retreating faces; it is in this sense, founded only upon appearance, that we have called VALVE the outer part of the mediastin, although really formed of two semi-valves, and that we have said that it bears the partition upon the middle of its inner part, although this partition, really double, arises from the two margins of neighbouring valves. This organization is found in Liliaceæ, Ericineæ, Tiliaceæ, &c. &c. It is modified, like septicidal dehiscence, by the existence or non-existence of the central axis, and by the more or less great degree of adhesion of the placentæ, either with each other or with the axis. Thus, in the Irideæ, all of which have loculicidal dehiscence, the placentæ remain united, forming a false axis in *Belamcanda*, whilst they accompany the partitions in most of the others, and especially in *Iris*.

2d. It happens in some families, such as the Cruciferæ,

Capparideæ, Fumariaceæ, and some Papaveraceæ, that the margins of the carpels which do not extend into the interior, or, if they do, by a very delicate lamina, are however so united together that they cannot separate at maturity. These united margins, together with the placenta, form kinds of thick, firm nerves: the rupture in this case takes place on each side along this nerve, the whole of the intermediate part of the carpel is detached and receives the name of VALVE, and the filament composed of the two placentæ, united to the margins of the carpels, is called the INTERVALVULAR placenta. An analogous phenomenon takes place in the Orchideæ.

3d. It happens in some genera, with what are called central placentæ, that the carpels, after fecundation, have a tendency to elongate beyond the placenta, the partitions being, at the same time, very delicate and easily broken, whilst the outer parts are strongly united together both at the base and apex; in these complicated circumstances, the union of which is consequently rare, the rupture takes place transversely across the middle of the carpels: we call this TRANSVERSE (*circumscissa*) dehiscence, of which *Portulaca*, *Anagallis*, &c. present examples. It is met with in the Lecythideæ with a peculiar combination.

4th. Among genera with central placentæ, the capsule of which elongates after fecundation, and by this means seems unilocular, at least at the upper part, it also frequently happens that the outer portions of the carpels remain united together the greater part of their length, but at the upper extremity, they have a tendency either to separate from one another or to split open along the middle nerve; this constitutes APICILAR dehiscence. It is observed in a great number of the Caryophylleæ: the number of the teeth is equal to that of the carpels

when each of them remains entire, and double this number when there is a fissure of the middle nerve. The same kind of dehiscence is produced in the Poppy by a different cause—the existence of the torus in a membranous state surrounding the carpels.

5th. The contrary, also, sometimes takes place, as in *Cuscuta*, for example, where the carpels are more united at the apex than at the base, and separate at maturity at the lower extremity; this constitutes BASAL dehiscence, which is almost always slightly irregular, and is nearly confounded with transverse dehiscence.

6th. Lastly, it sometimes happens, even in dry polyspermous fruits, that the carpels are so united together that they cannot separate or split regularly by any part of their surface; there generally result, then, towards the top of each carpel, kinds of pores, or irregular ruptures, which give passage to the seeds, but which can only be placed among dehiscences called IRREGULAR; we see it in *Linaria* and several other Scrophularineæ.

In indehiscent fruits, the true nature of the carpels is obscured by causes differing from the preceding; sometimes the fruits do not open, because the pericarps are membranous and dried up, and then there is usually an abortion of several parts; sometimes they are indehiscent because they are fleshy: and here we find the same distinctions as among fruits with isolated carpels; the flesh, which is only a development of the mesocarp, is found outside the cells, and the pulp is found inside them: there are fruits, as the Quince, which have flesh and pulp at the same time. Generally, in fleshy fruits, we cannot easily recognise the original position and place of the carpels, because the unions here are much more intimate.

A frequent cause of error in the manner of appreci-

ating the symmetry of fruits with united carpels, is the abortion of some of them, either wholly or in part. Thus, a fruit which, as *Lodoicea*, ought to have six lobes, is found to have not more than two or three, by the constant abortion of the others. A fruit of the Rubiaceæ, which ought to have two equal cells and a style springing from the centre, is found to have a single cell and a lateral style, as *Pleurogaster*. A fruit which ought to have three complete cells, is found, as the Pistachio, to have a single fertile cell, and two others, half or completely abortive, &c. &c. The number of similar examples is immense, for there are few families in which it is not met with.

The manner in which the carpels are placed with regard to the axis, deserves also to occupy our attention for a short time; the axis which supports the carpels, such as that which is observed in Magnoliaceæ or Anonaceæ, only becomes an integral part of the fruit when the carpels are united after flowering; the axis of the Malvaceæ, which is generally very visible, bears the carpels adhering by their inner margins, and the carpellary styles are either free or applied to it: we see this also in the Geraniaceæ, and, in general, in all fruits which have a true axis. But it sometimes happens that the carpels are articulated with a body which makes an integrant part of the style, and through which the vessels which carry the fecundating matter must necessarily pass; this is observed in the Ochnaceæ, for example, and it is the swelling of the base of the style which I have called the GYNOBASE. Some naturalists have confounded it with the axis properly so called; but there is this important difference between these two organs—the pistillary cord does not pass through the axis, which I consider an elongation of the pedicel destined to support the carpels, whilst it does pass through

the gynobase, which is nothing but an extraordinary swelling of the base of the carpellary styles united together. The true axis is usually elongated; but it is nearly globular in several Anonaceæ; it also takes this form and a fleshy consistence in the Strawberry, where it presents, moreover, the singularity of detaching itself from a kind of more solid axis in the centre; the carpels of the Strawberry are little granular styliferous bodies, dispersed over the surface of a fleshy body which serves for their nourishment, and is nothing but a round axis, to which several authors have given the name of POLYPHORE. These axes must not be confounded with the thecaphores, which form part of the carpels, of which they are, as it were, the petioles: the axes, on the contrary, are prolongations of the pedicel of the flower.

Hitherto I have always spoken of the carpels as being leaves folded inwards, or upon their upper surface; but it would seem that the inverse organization takes place in some Cucurbitaceæ; when the young fruits of this family are cut transversely, we find the carpels with their backs opposite the centre of the fruit, and the ovules are directed towards the side of the adherent calyx. Are these carpels folded in a contrary direction to all other plants, or have they twisted upon themselves before their development, so as to have the upper part of the carpellary leaf directed towards the outer side of the fruit? I am ignorant of this. I would venture to add here an observation which is at least singular:—M. Seringe found flowers of the Gourd, the anthers of which accidentally bore ovules, which were directed outwards, because the anthers are extrorse. Is there any relation between the extrorse direction of the anthers and of the carpels of the Cucurbitaceæ? Does this relation exist in other families? These are ques-

tions which I leave to botanists accustomed to the study of analogies, but upon which I cannot venture as yet to hazard an opinion.

Section IV.

Of Carpels considered with regard to their relation to the other parts of the flower which are persistent, or united around them.

We have seen in the preceding Section what results from the natural union of the carpels together, but that is not sufficient to form a complete idea of the modifications of the fruit; we must also study the pieces of the flower which form, or seem to form, part of the fruit at its maturity, viz.—the torus, the calyx, or the perigone.

The torus, as we have said, is the base of the male and corolline parts of flowers. It is sometimes prolonged around the fruit, either under the form of distinct petaloid scales, as in the Columbine; or of piliform filaments, as in several Cyperaceæ, and then it cannot produce any illusion: or under the form of a membranous cup which surrounds the carpels without adhering to them; thus in *Pæonia Moutan*, var. *papaveracea* it is thin and membranous; it surrounds the carpels without adhering there; it opens at its extremity to give passage to the stigmata, and as it does not dehisce it seems to make part of the fruit, from which however it is distinct. In *Carex* a similar cup is found, open at the top, and enclosing the solitary carpel without adhering to it, although it presses closely upon it.

In *Nuphar*, or the yellow-flowered Water-lily, we find a thick cup, green and shining externally, closed at the

top, and surrounding the membranous, polyspermous, verticillate carpels, which form the true fruit. During flowering and maturation, it seems to adhere strictly to the carpels, but at maturity it becomes detached at the base, and then we clearly see the distinction between these organs.

It is nearly the same in the Poppy; here the torus appears under the form of a thin lamina, which surrounds the carpels and completely adheres to them, except at the top of the ovary; the valves of the fruit, when they open at the top, are retained in their place by this adherent sheath of the torus, and it is this which causes the dehiscence of the Poppy under the form of teeth or very short valvules, and not throughout the whole length of the valves, as in the other Papaveraceæ.

The Orange only seems to differ from the preceding examples, in that the torus, which is thick and glandular externally, completely surrounds the carpels to the origin of the style, and adheres to them by means of very lax cellular tissue; remove this continuous torus, and you find the carpels verticillate around an imaginary axis, separable without tearing, of a membranous texture, and etiolated like all shaded organs; filled internally with a peculiar kind of pulp, which differs from that of all other fruits, in its being enclosed in kinds of utricles which arise from the walls of the carpels.

In the Capparideæ, Passifloreæ, and some Leguminosæ, the torus only adheres to the thecaphore, and the fruit itself is completely naked.

Such are the principal examples where we see the torus adhering to or surrounding the fruit, without the calyx or perigone following the same course. In *Nymphæa*, or white-flowered Water-lily, the stamens and petals are united at their base with the torus, whence it results that they seem adherent to the ovary; they are

destroyed after flowering, and the torus, which surrounds the fruit, is found marked with their cicatrices. I do not know any other example where we can find these organs adherent to the fruit. But frequently they remain without falling, and surround the base, as we see in the Campanulaceæ, Ericineæ, several Leguminosæ, &c. But these persistent stamens or petals, do not cause any remarkable differences in the history of the fruit.

Let us now see what takes place when the torus, and the calyx or perigone, united, adhere to the carpels, and form what is called an adherent ovary or calyx. Throughout the following, I only speak of the calyx for the sake of abbreviation, but the whole of the section is equally applicable to the perigone. This phenomenon necessarily supposes,—1st, that the pieces of the calyx or perigone are united together, so as to form a tube more or less prolonged ; 2d, that the torus is united to this tube, and consequently the stamens and petals are perigynous; 3d, that the carpels either adhere together or are reduced to one. All these conditions are frequently found united in the calyciflorous or perigynous families, in which alone the phenomenon can be met with. We frequently find in the same family every intermediate degree between the free and adherent calyx. Thus, we observe in the Rosaceæ, genera with the calyces free and expanded, and with the carpels distinct, as in *Potentilla* and *Spiræa:* others with the calyx free, and more or less cup-shaped, enclosing sometimes several carpels, sometimes a solitary one, without adhering to them, as *Alchemilla* and *Rosa;* and there are others (Pomaceæ) where the carpels cohere together, and are surrounded by the fleshy calyx, as the Pear and Medlar. Analogous transitions are observed in the Ficoids, Saxifrageæ, Caprifoliaceæ, &c. ; on the contrary, the adhesion of the

calyx with the ovary is constant in Myrtaceæ, Cucurbitaceæ, Umbelliferæ, &c.; it never takes place in Crassulaceæ, Salicariæ, and, perhaps, in Leguminosæ. This last family, however, presents in some cases a commencement of adhesion: thus, in *Arachis, Jonesia,* and some species of *Bauhinia,* the thecaphore or proper pedicel of the carpel, is laterally united with the calyx. From this fact, it is not impossible, perhaps, but that one day a leguminous plant may be found with an adherent ovary.

The adhesion of the calyx with the ovary, only takes place at the part where the torus is itself united to the tube of the calyx; consequently, if the tube be shorter than the ovary, the adhesion can only take place to a certain height, the stamens and petals will arise from the margin of the tube around the ovary, the upper part of which will be free, as in several Ficoids.

If the tube be as long as the ovary, which is most frequently the case, the adhesion will take place throughout the whole length of the two organs, the stamens and petals will arise at the point of separation, and only the limb of the calyx will be free; lastly, if the tube be prolonged beyond the ovary, and the torus also beyond it, the ovary is then entirely adherent, and surmounted by a tube, at the top of which arise the stamens and petals, as in *Œnothera:* in almost every case we remark at the top of the adherent ovary and around the style, a little space usually round, or with as many angles as there are sepals: this is the upper portion of the ovary, which is not covered by the calyx; sometimes it increases after flowering, and then forms a very evident mark upon the fruit; it is very large in several Cucurbitaceæ, and especially in *Cucurbita Melopepo;* it is also very remarkable in the Medlar, in several Rubiaceæ, and, when carefully observed, we find it in almost all, or perhaps in all adherent fruits. This exposed portion of

the ovary is usually very smooth, and is thus distinguished from the calyx. Outside this disc formed by the ovary, we find a small circular zone, which is the trace of the point where the torus terminates. This zone is very easily perceived when, as in the Pomaceæ, the stamens are more or less persistent on the fruit, or, as in the Campanulaceæ, where the corolla itself is persistent; it is also very visible when, as in several Cucurbitaceæ, it increases after flowering: I suspect that it is the torus, perhaps, which is prolonged a little after the flowering, and forms, in the Rubiaceæ, the little cup which is found between the limb of the calyx and the base of the style. In most adherent fruits this zone, produced by the torus, is effaced at maturity.

The disc, formed by the naked part of the ovary, the zone, produced by the torus, and especially the rest of the free part of the calyx which remains, or leaves, at least, some trace at the top of the fruit, form by their union what is called the Eye, visible in this class of fruits, for example, in the Pear.

The tube of the calyx, united with the ovary, may, according to its texture, be moulded to the form of the fruit, or compel the fruit to take its form; but most usually the two bodies are modified a little in their general form. Its texture is also variable: sometimes it remains foliaceous or membranous, and then the fruit is dry; at other times it becomes fleshy with the ovaries, and sometimes grows to a considerable size; most frequently it is impossible, in adherent fleshy fruits, to distinguish which is the part which is transformed into flesh; thus, in the Pear, for example, it may be either the development of the sarcocarp of the carpels, or of the torus, or of the calyx, or, what is most probable, of all the parts at once.

The adhesion of the calycinal tube with the ovary is

usually intimate and lasting; but it happens in some cases, such as *Cosmibuena*, a genus of the Rubiaceæ, near *Quinquina*, that at maturity it becomes detached from the ovary, and only covers it over without exactly adhering.

The free part of the calyx is presented under very different forms, which influence the appearance of the fruit and frequently its history; it is sometimes scarious, sometimes membranous, and sometimes completely absent, either from the time of flowering or at maturity.

When the entire tube of the calyx is united with the ovary, and its lobes do not undergo any change, they remain at the top of the fruit under the form of teeth, as in *Œnanthe* or *Conium*, or they form a kind of eye, as in the Pear or Apple.

If the tube be prolonged beyond the ovary and harden after flowering, it results that the fruit is crowned with a kind of peculiar collar, as in the Pomegranate and some species of *Gardenia*.

Sometimes these lobes enlarge, remaining foliaceous, or becoming slightly fleshy after flowering.

We have seen, in speaking of the modifications of flowers, that it constantly happens in those which are collected into a compact head, and sometimes in others, that the limb of the calyx has a membranous and scarious texture: in this case it remains at the top of the fruit, and the name of PAPPUS is given to it.

Its function only begins to be important at the time of the dissemination of the seeds.

These scarious calyces sometimes have their lobes united into a single entire or toothed body, which causes the fruit to be crowned with a scarious cup, as in *Favonium*, *Chrysogonum*, *Scabiosa stellata*, &c. At other times each lobe remains distinct, and takes either the form of a little scale, as in *Apuleia*, *Centaurea Crupina*,

&c., or that of a long process, as in *Pectis.* Most frequently each lobe is, as it were, replaced by a greater or less number of scales in the form of hairs, which are called the hairs of the pappus: they are sometimes simple and free, and then the pappus is said to be HAIRY, as in *Sonchus;* sometimes irregularly united together, and then the pappus is BRANCHED, for example, in *Stæhelina;* sometimes toothed on the margins, as in *Hieracium* and *Chondrilla;* sometimes bearded laterally, as in *Scorzonera,* and then the pappus is FEATHERY.

The pappus, which is called STIPITATE, is produced because the calyx, and perhaps an elongation of the pericarp, is prolonged perceptibly above the point where the seed terminates; as this portion is empty it remains thin, filiform, and appears, at first sight, rather a support of the pappus than a part of the fruit; we see it in *Tragopogon,* &c.

It sometimes happens that the pappus is in two rows, which do not resemble each other. In this case, the outer row is certainly the limb of the calyx; but I should not be surprised to find it proved that the inner row is a prolongation either of the torus, or of the pericarp; this is observed in some species of *Centaurea.*

The limb of the calyx of the Valerianeæ, during flowering, is rolled inwards, so as only to present a small circular limb; it afterwards unrolls, and the fruit is crowned with a feathery pappus; the Proteaceæ have a kind of pappus which is formed by the limb of the perigone.

Finally, the limb of the calyx is sometimes completely absent; this phenomenon may take place even during the time of flowering, when the whole of the calyx is united with the ovary, as happens in most of the Umbelliferæ; still even in this case the lobes almost

always exist, but reduced to very small teeth. The entire absence of the limb is more visible in those Compositæ without a pappus, as the Daisy, &c.; the limb is here indicated by a small circular rim, entire or unequally toothed.

In other cases the limb is visible at the period of flowering, but it is destroyed or detached naturally at maturity; we observe this in *Epilobium*, &c.

Nyctago and the Marvel of Peru present, in this respect, a phenomenon worth mentioning: the base of the perigone, united with the ovary, forms a kind of oval nut, and the upper part separates immediately above it, after flowering, and falls off, the nut remaining within an involucrum which has the form of a calyx.

It is not necessary that the calyx should be, strictly speaking, adherent to the ovary so as to form an integrant or apparent part of the fruit; thus, for example, in the Rose, the carpels are dispersed in a kind of cup, which forms the tube of the calyx; they adhere to it only by their bases; after flowering, the calyx and torus unite together, increase in size, and become very fleshy, principally in the inner part. The internal cellular tissue penetrates between the bony, indehiscent, monospermous carpels, which appear to be simple seeds contained in a pulpy pericarp, whilst they are caryopses embedded in a calyx become fleshy.

In a great number of plants, and especially in the Monochlamydeæ, the calyx or perigone, without adhering to the ovary, covers it over so closely that it absolutely seems to form part of the fruit; in this case it sometimes remains membranous, as in *Atriplex*, and at other times it becomes fleshy, as in *Blitum*.

When the calyx, without adhering to the ovary, remains around the fruit in a looser manner than in the preceding case, we are contented to say that the fruit is

Covered, when, as in *Physalis*, the calyx has a tendency to be closed at the top, and thus entirely surrounds the fruit; we say that it is Concealed, when the persistent calyx only surrounds it in part, as in *Nicandra* or *Hyosciamus*. The calyces of the Labiatæ are tubular, persistent, and contain four monospermous caryopses; after flowering, in certain genera, their lobes close in together, and the fruits may be said to be covered; in others they remain more or less open, and the fruits may be said to be concealed; in this last case, it almost always happens that little hairs, which are not perceived before on the inner face of the calyx, are developed after the fall of the sexual and corolline parts; they close the entrance of the tube, and protect the young fruit from rain and insects.

Section V.

Of the Organs situated outside the Flower, and which sometimes seem to form Part of the Fruit.

Not only can the organs of the flower, in certain cases, become integrant or apparent parts of the fruit, but the same thing may happen with the bracts or involucra as well as the peduncles and receptacles.

All that I have said of the calyx or perigone, in their connexion with the fruit, may almost apply to the bracts or involucra, observing only that the examples are much less numerous; thus, we sometimes find bracts which adhere to the calyx, or cover it so intimately, that they seem part of the fruit: in *Scolymus*

Hispanicus, the bracts, from the axils of which the flowers are developed, surround the ovary so closely and are united to it in such a manner as to seem an integrant part of the fruit; it is this which caused Gærtner to give it the name of *Scolymus angiospermus*.

In *Echinops*, the bracteoles, which collectively form the involucellum, perform the part of a calyx towards the ovary, being united with it and forming a kind of false scaly pappus.

In *Lagasca*, the involucellum surrounds the achenium without adhering to it, and seems to be a cup-like calyx around the pericarp.

In all the Compositæ and Dipsaceæ with a double involucrum, the bracts, which form the involucellum or proper involucrum of the flowers, present, more or less distinctly, analogous phenomena.

Lastly, to mention other families, the bracts of *Pollichia* become fleshy after flowering, and are easily taken for an integrant part of the fruit, which they cover; the foliaceous involucrum of the Hazel seems to form part of the fruit; the cup of the Acorn is a true involucrum formed by the union of a great number of little bracts, and the Acorn, like the Nut, is a fruit formed by an ovary adherent to the calyx. These two examples present a rare peculiarity in the vegetable kingdom, viz.:—a fruit which adheres by a large portion of the base, which at the time of separation caused a great cicatrice like that which is most commonly seen in seeds. This cicatrice of the fruit, or CARPAL CICATRICE, ought to be distinguished from that of seeds, or the hilum, of which we shall shortly speak.

The peduncles themselves sometimes seem to form part of the fruit; thus, in *Semecarpus* and *Anacardium*, they enlarge after flowering, become fleshy, and take the form of a Pear, whilst the true fruit, which is dry,

is situated at their apex, seeming to be a kind of excrescence.

In *Hovenia dulcis,* they also become fleshy after flowering, and seem to form the true fruit.

Section VI.

Of the Aggregation of Fruits which proceed from different Flowers.

The facts mentioned in the preceding section lead us to the study of Aggregated fruits, or those formed by the intimate or apparent union of fruits proceeding in reality from different flowers. This phenomenon never occurs but in plants where the carpels are solitary and most frequently monospermous by abortion; it likewise almost always supposes, as necessary conditions, on the one hand that the solitary carpel is united to the calyx, and on the other that the flowers are placed very near together. I shall explain this by examples derived first from capitate or umbellate flowers, and afterwards from those in spikes.

Honeysuckles have naturally two flowers which arise from the same axil; their pedicels are frequently united into one, which consequently bears two flowers and two berries; but it happens in several species, as for example, *Lonicera Xylosteon,* that the two fruits are more or less united into a single one, bilobed or almost entire; in this last case, the union is perceived, either because, during flowering, we saw two corollas upon an apparently single ovary, or because, after this period, we recognise the two eyes which indicate the fall of the

sexual parts and appendages of the adherent ovaries. In *Symphoricarpos*, a genus so near *Lonicera* that it was for a long time united with it, instead of there being only two flowers, there are several united by the ovaries, whence there results a fruit composed of several joined together, each of which still presents its own eye: the same occurs in *Morinda;* it is also met with in *Opercularia*, with only this difference, that the flowers, which by their near approach form a compact head, have not a fleshy fruit, but their calyces and bracts are all united together: at flowering, we see all the corollas distinct—at maturity, the fruit is slightly irregular, and composed of all the partial ones joined in a head. The same thing takes place in the Compositæ, in *Gundelia;* here the bracteoles united together surround the partial fruits, so that at maturity there results a mass composed of the receptacle, bracteoles, and achenia of all the flowers of which the head was composed.

The fruit known under the name of Fig, is a remarkable example of aggregation, analogous to the preceding cases: it is either a hollow pedicel, or rather (if attention be paid to those exotic species which have scales externally), a kind of fleshy involucrum, formed of a great number of thick bracts intimately united at the base either with each other, or with the top of the peduncle, and very slightly free at their extreme apex. The flowers are very numerous within this involucrum, the top of which is scarcely open; the female ones, which are the most numerous and more central, are transformed into as many little caryopses as there seem to be seeds, and which, at maturity, are as nuts in the centre of this fleshy or pulpy involucrum: it may be said, then, that there is no other difference between the fruit of the Fig and that of the Rose, except that the pulpy part of the Fig is an involucrum, and that of the Rose a calyx; that, consequently, the seeds of the former are caryopses

proceeding from different flowers, and those of the latter caryopses proceeding from but one flower.

What I have said of the Fig becomes still clearer when we compare it with the neighbouring genera *Ambora* and *Dorstenia*, in which the receptacle is open.

Flowers disposed in spikes sometimes present all the phenomena which I have above mentioned; thus, when we follow the Mulberry from its flowering to maturity, we see that the flowers are sessile on an axis which is articulated at its base; after flowering, the ovary is covered by the perigone, and is transformed into a small pulpy fruit; all these fruits are united incompletely together, and appear the more readily to form a single one, as the general peduncle disarticulates at its base, so that the Mulberry is detached from the tree like simple fruits. All that I have said of this fruit is strictly applicable to the Bread-fruit, except that in the latter the partial fruits are more completely united, and the whole fruit which results from the aggregation is larger, and the flesh more farinaceous; and as for the cultivated Bread-fruit, we may add that the seeds are almost always abortive, leaving their places empty, which forms the irregular cavities in the centre of the mass.

The history of the Pine-apple slightly differs from the preceding examples: the flowers are disposed in a dense spike along the stem, almost as in *Eucomis;* after flowering, the flowers which have the perigone adherent to the ovary, are each transformed into a fleshy fruit, originally trilocular; these are united first with the bracts situated at their base, afterwards with each other; the development of the fleshy part, and the intensity of the union, are greater in proportion as the number of abortive seeds is great; and when they are all abortive, as in the cultivated ones, there results a compact oval head, in the centre of which we see, as in the Bread-

fruit, empty cells which indicate the abortion of the seeds, and externally kinds of scale, which are the persistent remains of the bracts and lobes of the perigone; the whole is crowned with a tuft of leaves, which are nothing but foliaceous bracts devoid of flowers, which spread out at the top of the spike, as in *Eucomis*, and the development of which is favoured by the abortion of the seeds of the lower flowers.

The fruits of the Coniferæ present phenomena very analogous to the preceding. If we examine the female cone of a Fir, we find small flowers sessile in the axils of the bracts, and disposed in a spike along an axis; after flowering, the flowers which have the perigone adherent to the ovary are each transformed into a kind of nut, or samara, and the bract, which grows much, completely covers the fruit; this assemblage has received the name of CONE; its axis is sometimes accidentally prolonged into a leafy branch (Pl. 16, fig. 4), which is similar to what constantly takes place in the Pine-apple. The cones of the Proteaceæ, and the follicular heads of the Hop, present an analogous organization; these kinds of cones differ from those of *Magnolia*, or the Tulip-tree, in proceeding from the aggregation of the carpels of several flowers in a spike, whilst in the Magnoliaceæ, they are formed by the aggregation of several carpels in a spike proceeding from a single flower.

But there are some Coniferæ where the phenomenon is complicated in consequence of the form or texture of the organs. Thus, in the Pine, we find the same general disposition; but the bracts, after flowering, enlarge and become very thick at the top, so as to form a close mass, which only opens shortly before their separation; the Cypress and *Thuja* have these same bracts less numerous, and so dilated at the top that they

form kinds of convex discs and pedicels; the cone, which has then very improperly received the name of nut, has a globular appearance; it is close and semi-fleshy in its young state, but at maturity it becomes dry, and the scales separate by kinds of slits which give passage to the caryopses or achenia which they enclose, and are usually falsely called seeds. The Juniper differs from the Cypress only in the bracts, thick at the top, being fleshy and much more united, whence it results that the fruit at maturity presents the appearance of a globular berry, which name it has improperly received: the traces of the union of the bracts are hardly perceptible, and the enclosed caryopses have still more the appearance of simple seeds. Thus the apparently simple berry of the Juniper is formed by the natural union of fruits proceeding from several flowers, nearly as the berry of several species of *Anona* and of *Dillenia* is formed by the natural union of the carpels proceeding from one flower.

These apparent affinities between the fruit of different classes, have frequently caused analogous terms to be used in popular nomenclature. The fruits of the Chestnut *(Æsculus)* and those of the Horse-Chestnut have a very great external resemblance. The Chestnut, seen at the time of flowering, presents several female flowers, collected in an involucrum, which enlarges and becomes very spiny; each flower has an ovary surrounded by an adherent calyx; this ovary is formed of three united carpels, each containing two ovules: during and after flowering, several of the seeds become abortive; and there sometimes remains but one.

In the Horse-Chestnut, on the contrary, the flowers are perfectly distinct, and the calyx is not adherent; the ovary is formed of three carpels united into a body, bristly externally, each of which encloses two ovules;

but during and after flowering, several of them become abortive, so that the capsule frequently has but two cells and two or three seeds.

Thus, the spiny husk of the Chestnut is an involucrum, that of the Horse-Chestnut a capsule. The brown, shining, round bodies of the Chestnut are achenia, furnished at the base with a large carpal cicatrice; those of the Horse-Chestnut are seeds with a large spermal cicatrice. The bodies enclosed in the brown envelope of the Chestnut are distinct seeds; those within the brown skin of the Horse-Chestnut are the cotyledons, or portions of the seed. Although this example is trivial for botanists, I thought that I ought to mention it in detail for beginners, because, better than all reasoning, it proves the necessity of referring to the period of flowering in order to comprehend the structure of fruit.

Section VII.

Of the Umbilical Cord and its Expansions.

We have already said, that the Funiculus or Umbilical Cord proceeds from the placenta, and supports the seed; that it is composed, during flowering, of the filament proceeding from the style and bearing the fecundating fluid, and of a fibre coming from the pedicel and carrying the nourishment; that after this period, the pistillary filament is obliterated, and the funiculus remains formed of the nourishing fibre alone: we may consider it as making part of the pericarp, either on account of its texture analogous to the placenta, or because that, at maturity, it usually happens that it remains adherent to the placenta when the seed is

detached; but this last character is subject to several exceptions, and we shall presently see that it is often difficult to fix the precise line of demarcation between the pericarp and the seed.

The funiculus is usually presented under the form of a short and scarcely visible filament; it is very long either in those fruits where the cells are large, as certain Mimoseæ, or where it is curved or folded, as in the same plants, in some Cruciferæ, &c., or where it is destined to support the seed when out of the cell: thus, in *Magnolia*, the free carpels, of which the fruit is composed, open along their dorsal suture, and the one or two seeds which they contain hang out, supported by a long, slender, silvery-white, and flexible funiculus. It has been remarked, that it is a bundle of tracheæ; I do not know that any similar observation has been made upon the funiculi, which, in almost all other plants, are not capable of being extended.

The funiculus is usually free from all adhesion; but there are plants in which, being very near together, they are constantly united; this is observed among the Cruciferæ in the genus *Eunomia*. It more frequently happens that it is found naturally united with the walls of the cells; thus, for example, in some Cruciferæ, such as *Lunaria* or *Petrocallis*, the funiculus is united, throughout its whole length, with the partition in the middle of the fruit. In some Mimoseæ, it adheres to the valve from which it originates; in these cases, the seed, although arising from the margin of the carpel, seems to proceed from the middle of the partitions or valves. It is possible that it may be from analogous adhesions of the umbilical cord and not of the placenta, that arises the position of the seeds of the Flacourtianeæ and Butomeæ, scattered over the inner valves of the fruit.

When the funiculus of a free carpel or of a cell of

the fruit arises from near the base, if it be short, the seed is necessarily erect, for example, in all the Compositæ; if it be long enough to reach the top of the cell and then curve at its extremity, the seed, although originating from the base, is found pendent; as is seen in the upper cell of the fruit of *Crambe,* in the fruit of *Paronychia,* &c.

Let us suppose, now, that the nourishing cord is long, ascending, and united to the wall of the cell, the seed is attached to its extremity, and appears pendent from the top of the cell, as, for example, in the Dipsaceæ; in this case, as in the preceding, one of the margins of the fruit presents a small nerve; in the first, this nerve, which is very delicate, is produced by the pistillary cord, in the second, by the nourishing cord.

When the seeds arise from the margins of the carpels, or from the inner angle of the cells, they are naturally horizontal; but when the funiculus is long, and especially in pulpy fruits, it happens that they take a pendent or uncertain position according to the development or particular position of the fruit, or according to their own weight. Thus the length, adhesions, and inflexions of the umbilical cords, or of the pistillary and nourishing cords, determine the general position of the seeds in the cells of the fruit or in the carpels, combining these characters with those above mentioned, with regard to the position of the placentæ and the number of seeds.

The umbilical cord always bears the seed at its extremity, and the part of the seed to which it adheres is that which is called the UMBILICUS, HILUM, or CICATRICULA; but as this cord has a tendency, in several fruits, to expand a little before reaching the seed, these expansions have received the name of ARILLUS; and their history is the more important, as, in certain cases, one

is inclined to confound them sometimes with parts of the pericarp, at other times with those of the seed.

The most simple cases are those where the funiculus expands laterally, so as to form an appendage upon the seed; thus, in several Polygaleæ, we find a lateral arillus which evidently arises from the funiculus. In this case, it is usually fleshy or membranous; it is, perhaps, to this order of unilateral arilli, that the carunculi which are found in some species of *Dolichos* and in *Chelidonium* ought to be referred. In the Nutmeg the arillus is large, fleshy, and ramified, forming a kind of incomplete envelope at the base of the seed; it is what is commonly called Mace: in *Blighia* it is so large and fleshy as to be worth the trouble of collecting for food. The same phenomenon occurs in the Passifloreæ, where the inside of the arillary coat is full of a pulp secreted apparently by the walls of the arillus; when abundant, it causes some capsules of the Passion-Flowers to be classed with edible fruits.

In all the examples which I have mentioned, the arillus forms an incomplete envelope around the seed, and this is what ought to be considered the distinctive character of this kind of expansion of the funiculus.

We give, on the contrary, with Gærtner, the name of Epidermis, to a dry, thin, membranous sac which entirely covers the seed; this organ is very visible in the Malvaceæ, Bombaceæ, &c.

It is to be remarked that the arillus, whether it be fleshy, membranous, or pulpy, never bears hairs; on the contrary, the epidermis is sometimes smooth, as in the Gourd, but more frequently furnished with hairs; and as the skin of the seed, properly so called, never bears hairs, whenever a seed appears so covered, it is because it is invested with a very adherent hairy epidermis; these hairs are either very short, as in most Mallows, or very

long, as in *Gossypium*, where they form the substance so celebrated and useful, called COTTON; sometimes they are found scattered over the whole surfaces of the epidermis, as in *Ochroma;* sometimes only in certain places, as in several varieties of the Cotton Plant: sometimes in a tuft at the extremity of the seed, as in several Apocyneæ. These tufts, which have been called CRESTS, (*comæ*) so resemble pappi, that they have frequently been confounded with these organs; but they present this essential difference—that the pappus, which is a degeneration of the limb of the calyx, is on the outside of the pericarp, and the crest, which is an extension of the epidermis, is within the cells of the fruit, and upon the seed itself. Notwithstanding this important anatomical difference, their nature and properties have a great analogy. These two kinds of tufts are formed of membranous and very hygroscopic hairs, endowed with the faculty of approximating when moist, and diverging when dry; whence it results, that as long as the maturation has not been completed, these hairs, being moist, remain close together; but becoming dry at maturity, they diverge, and thus tend to facilitate the bodies to which they are attached in coming out of their envelopes. The pappus draws the achenium out of the involucrum; the crest carries the seed out of the pericarp; both of them, being expanded, permit the least wind to bear to a distance these little bodies, to which they perform the office of wings, or rather of parachutes. I shall now revert to the modifications of the epidermis.

It frequently happens that this membrane is expanded around the seed, and, instead of bearing hairs, is dilated into a wing frequently well developed and very delicate. It is thus that in several Apocyneæ, Malvaceæ, &c. the seed is terminated, surrounded or enclosed by a membranous wing, which, like the crest, contributes to

facilitate its passage and dissemination. But it must be observed here, that this wing resembles several very different organs, or rather that analogous expansions may be developed upon almost all the organs of the fruit: thus, although I am inclined to believe that the greatest number of winged seeds owe this organization to the epidermis, it is nevertheless possible, that sometimes the skin itself of the seed may be expanded into a wing; this seems to take place in the Bignonias with winged seeds; and I confess that, seeing the adhesion and fineness of certain epidermes, I scarcely know any means (except analogy) to ascertain if the wing of a seed results from its own covering, or from its epidermis. The carpels themselves may expand into wings, as in the solitary ones of *Nissolia*, &c., or in those united into a single fruit in the Elm; calyces adherent to the ovary and becoming part of the fruit, form membranous wings, either by the expansion of their limb, as in several Dipsaceæ and Compositæ, or by the expansion of their angles, as in several Umbelliferæ; and what is remarkable in this degeneration, as well as in the preceding, is that the physiological function of these expansions is absolutely the same in every case, whatever be their anatomical origin. The wings always serve for the dissemination either of the seeds properly so called, or of the carpels or fruits which contain but one or two seeds; for they are hardly ever formed upon polyspermous fruits. Thus they always serve in the end, wherever they may be placed, to separate the seeds from one another for their natural dissemination.

I believe that it is also to the presence of a very delicate, but hygroscopic epidermis, that we must attribute a curious phenomenon, viz.—the faculty of certain seeds of absorbing moisture, and of being found, when placed in water or wet earth, surrounded by

an aqueous pulp, retained around them by a very delicate membranous net-work; *Lepidium sativum*, the common Flax, and several other seeds, exhibit this phenomenon, which must tend to facilitate their germination.

Among the different examples of the accessory integuments of seeds which I have mentioned, the origin of the arillus, as a prolongation of the funiculus, is very evident; but the origin of the epidermis is much less so; it may be considered as proceeding also from the funiculus on account of its position around the seed, and because it is evidently an organ in addition to those which essentially compose the seed.

CHAPTER IV.

OF THE STRUCTURE OF THE SEED OF PHANEROGAMOUS PLANTS.

Section I.

Of the Seed in general.

A Seed *(semen)* considered with regard to the flower, is a fecundated ovule; considered individually, it is a cavity closed on all sides, containing the rudiment of a plant. It is composed of the embryo or germ, which has received the fecundation, and of its different appendages, some of which serve as nourishing organs, and the others as protecting integuments.

The seed properly so called, such as I have defined it, must be distinguished from monospermous fruits and tubercules; thus, it may be confounded, as it frequently has been in botanical, and as it constantly is in ordinary language, either with a monospermous pericarp adherent to the seed, as the caryopsis, such as the seed of the Wheat, or with the body which proceeds from the union of a solitary seed with the pericarp and calyx, as the achenium of the Compositæ; or with this same achenium also united with the involucellum, as in *Scolymus.* In all these cases the seed forms part of the body to which it gives its name, but it is not isolated, and unless one take care to separate it, either really or in imagination, from the organs to which it is joined, it will be impossible to understand its description.

On the other hand, one is often inclined to take for seeds, the tubercules or bulbs which are produced in certain parts of plants, but which are germs developed without fecundation. The distinction of the seeds from these bodies is often very difficult, sometimes impossible; therefore, to avoid all uncertainty, I shall derive all that I have to say from the seed of plants in which this doubt does not exist, and I shall leave for the following chapters the examination of the doubtful cases.

A seed may be considered as a germ which is developed in the axil of a leaf, curved upon itself in the form of a closed envelope. This fecundated germ takes the name of EMBRYO; the leaf which surrounds it, that of SPERMODERM *(spermodermis)*, or skin of the seed: these are the only two organs essential to the ripe seed. We sometimes find in the spermoderm another body, which is called ALBUMEN, and which deserves special attention; the spermoderm, albumen, and embryo, will be, then, the three parts which we shall have to study.

The umbilical cord bears the seed at its extremity; the trace which it leaves upon it after it is detached, or, in other terms, the place by which it adhered to the funiculus, is its CICATRICULE *(cicatricula)*, also called HILUM or UMBILICUS: this place is always considered as the base of the seed; the apex is not determined anatomically, as in the fruit, where the trace of the style clearly indicates it; whilst the seed does not give origin to any other organ, but it is found convenient to call the ideal AXIS of the seed, the straight or curved line, which, arising from the base, proceeds at an equal distance from the margins; and we name the APEX the extremity of this line. It evidently follows from these definitions—1st, that the base of a seed is nearest the pedicel of the fruit in erect seeds, nearest the axis or walls of the fruit in horizontal ones, and nearest the style in pendent ones; 2d, that the position of the seed is only considered with regard to the pericarp, and not to the rest of the plant; thus, when a fruit is pendent, we say that the seed is erect, when its apex is directed towards the earth; and that it is pendent if its apex point towards the sky.

The abortion of the ovules or seeds, either before fecundation, during flowering or at maturity, is a phenomenon so frequent, that it might be said, without exaggeration, that it is rare to find fruits, all the ovules of which have arrived at the state of ripe seeds. It may be caused by the slightest derangement, either in the fecundating or nourishing apparatus of the ovules; and even when these two systems of organs are in a perfect state, and when no external accident deranges them, there are still two frequent causes which produce these abortions:—

1st. The more or less lateral position of the flowers with regard to the axis either of the spike, branch, or

stem itself, causes an inequality in the facility with which the sap penetrates the different sides of the flower or fruit, and the less favoured sides often present abortions.

2d. The fecundation cannot take place upon all the stigmata at once, and the fecundating vessels which go from the stigmata to the ovules, do not carry the fovilla to all of them at the same time. When the ovules do not grow rapidly after fecundation, this inequality in the period of fecundation does not cause any abortion; but if one or more of them grow rapidly, then they tend to render the others abortive, either by attracting all the nourishing sap, or by compressing or obliterating the filaments of the pistillary or nourishing cord of the other ovule. As these causes are connected with the original structure of each species, the abortions which result are nearly constant, as we clearly see in the Oak, Horse-Chestnut, *Lodoicea*, &c.

The unions of the seed with parts of the pericarp, have already occupied our attention; but I ought to mention here the accidental union of them with one another, a rare phenomenon, and of which I have as yet only seen a positive example, shown to me by M. Heyland: it is that of two seeds of the Horse-Chestnut, which were united together half-way. I mention this fact, not only on account of its rarity, but because it may lead to the explanation of another, more important and less rare, viz.—the plurality of embryos in one seed. This fact is frequent in different species of the Aurantiaceæ; thus, the Orange has usually three or four, and it is accidentally observed in some other plants, as in *Ardisia coriacea*. Richard does not hesitate to regard this plurality as monstrous. I should be inclined to believe that it results from the incomplete union of two or more ovules, the spermoderms of which united to-

gether do not seem to make more than one, and the embryos of which are developed simultaneously. Whatever be the cause, this plurality of embryos does exist in some seeds, and they are sometimes isolated from one another, and at other times united together. This last case has been observed by my son: having remarked a plant of *Euphorbia Helioscopia*, (Pl. 22, fig. 1,) which came up with four cotyledons, he perceived that this number was owing to there being two embryos united together throughout their whole length; he has since observed in *Lepidium sativum*, and *Sinapis ramosa*, this same monstrosity, which bears the same relation among plants to the monstrous animals formed by the union of two young ones. We know that in these animal monstrosities, it frequently happens that a part of the organs of one or both of them disappears; it is in this way that calves with two heads, or six legs, &c., are formed. The same happens in the union of embryos; some instead of four cotyledons, have but three; this is what is observed in the *Euphorbia* and *Lepidium* of which I have spoken, and in *Ranunculus*, *Solanum*, the Bean, &c. &c. In order to complete what relates to the plurality of embryos, I have slightly deviated from the natural order of facts, to which I now return.

The seeds of the same plant are not all exactly of the same size; in most cases this difference is of little importance, and we generally select the largest seeds for sowing, because it is remarked that the plants proceeding from them are more vigorous. But in some cases this difference of size has a peculiar interest; thus, M. Autenrieth has remarked that among the seeds of the Hemp, which is a plant constantly diœcious, the longest, largest, and heaviest, produce male plants, whilst those which are rounder and less heavy, produce female ones; the former have a longer radicle, and germinate

more quickly than the latter. Similar observations have not as yet been made upon other diœcious plants, so that it would be imprudent, in the present state of our knowledge, to affirm if these laws be more or less general.

The weight of seeds is much more capable of being appreciated: in general, ripe and fecundated ones are heavier than water, and this law appears to be universal. Seeds which have not attained maturity, or the embryo of which has not been fecundated, are almost always lighter than water, a practical character which enables all gardeners to distinguish good seeds from bad: it must be remarked that good ones may swim when they retain a stratum of air, confined around them by means of hairs, wings, or cavities which may surround them.

Section II.

Of the Spermoderm, or Skin of the Seed.

The proper skin, envelope, or coat of the seed, is an organ so distinct, that it was very right to give it a name. Richard, from analogy with the word pericarp, proposed that of Perisperm, and afterwards that of Episperm; but these terms do not seem to me to be admissible; the first, because Jussieu used it in another sense; the second, because, having no similarity with the sense of the word epicarp, it would produce confusion. I have replaced them by the term Spermoderm, which expresses, in one word, the skin or coat of the seed; this envelope exists in every seed, and I cannot admit what Mirbel says of its absence in some; Gærtner considered it as formed of two membranes, which he

called the testa and the inner coat; but if I differ from the nomenclature of Richard, I entirely adopt his opinion upon the nature of this envelope. It is, like all foliaceous organs, composed of two membranes and of an intermediate tissue; the external one bears the name of TESTA, the internal one that of ENDOPLEURA, and the intermediate plexus that of MESOSPERM; these three parts form, by their union, the close coat without valves or sutures which surrounds the nucleus.

The testa, when deprived of all the accessory integuments, which the arillus, pericarp, calyx, or even the involucrum may furnish it with, appears most frequently under the form of a shining membrane; sometimes, however, it is rough as in the Tulip, or marked with little tubercles or furrows, as in *Oxalis*. But in general, it is smooth, even glossy, dry, scarious, osseous, or almost petrous, as in *Guilandina Bonduc*.

Notwithstanding this appearance, it is eminently endowed with the faculty of absorbing water, and performs, in this respect, an important office in germination. It also presents this singularity—that although the microscope can discover no kind of pores, it not only absorbs water, but even the coloured particles of this fluid, tinted, for example, with cochineal; this progress of absorption is entirely analogous to what takes place at the extremities of the radicle and in the stigma, which obliges me to consider the testa formed of seminal spongioles; its colour presents much variety, and affords here and there, especially in the Leguminosæ, the most vivid and glaring tints; for example, in *Abrus*, *Erythrina*, Beans, &c.

The testa is interrupted at the point where the umbilical cord is attached to the seed; this forms the hilum, to which I shall presently revert: this interruption seems to indicate that this organ, like the epidermis of

leaves, owes its existence to its being more exposed to the air than the other parts of the spermoderm: what confirms this opinion is, that sometimes the testa cannot be distinguished, or at least, is not of its usual texture in all seeds which are invested with an epidermis, and especially in those which are united to the pericarp.

The endopleura, or inner coat of the spermoderm, is exactly in the seed what the endocarp is in the fruit, that is to say, the upper face of the leaf folded upon itself; this membrane never has either the shining appearance or solidity of the testa; it is almost always of an uniform white colour, and composed of a cellular tissue, which, one would think, ought readily to absorb water; but the case is quite the contrary, for it contains the aqueous juices of the young seeds without absorbing them, and at the period of germination it prevents the water from passing directly to the embryo. The endopleura seems moulded upon the NUCLEUS of the seed (this name is given to the whole of what is contained within the spermoderm); but, in reality, it is the nucleus that is originally moulded, as it were, in the empty space within the spermoderm, which, when it begins to grow, it distends.

The endopleura, at a certain point which is called the CHALAZA, gives passage to the vessels which bear the nourishing or fecundating juices to the embryo.

The mesosperm is in the seed, what the mesocarp is in the fruit; that is to say, the plexus of fibrous vessels and of cellular tissue which is found between the two membranes; in fact, it is most frequently a very delicate and scarcely apparent fibrous plexus; it takes a fleshy or pulpy consistence in but a very small number of cases, as, for example, in *Magnolia*, *Iris fœtidissima*, &c. The seeds which have this peculiarity, are named SEMINA SACCATA in descriptive works; the dry and

brittle nature of the testa causes it to adhere less to the mesosperm than this latter does to the endopleura; it is on this account, that those carpologists who say that there are but two membranes in the spermoderm, have united under the name of inner coat or hilofer, the endopleura and mesosperm.

The fibres which form the mesosperm generally arise from the hilum, and expand between the two membranes of the spermoderm; they fulfil two offices, and are, perhaps, of two different natures; the one kind, which may proceed from the umbilical cord, may bear nourishment to the embryo and spermoderm during maturation, and when maturity has arrived, may be obliterated; the other kind, which may be directed from all parts of the surface, towards the point of the endopleura where the embryo is situated, may be for the purpose of bearing thither the water absorbed during germination. These two orders of fibres have not as yet been accurately distinguished; but those which are employed during germination may be observed, by causing large seeds to germinate in coloured water. I have employed those of the Broad Bean, and have very well seen the fibres of the mesosperm become gradually coloured, when introduced into cochineal water; I have even seen the colour reach the embryo. In selecting any large seed where the position of the chalaza may be different from that of the hilum, we might decide, by direct experiment, the as yet obscure problem of the nature and direction of the fibres of the mesosperm.

The portion of the seed where the testa is absent is, as we have said, the hilum; here we may distinguish two parts: the one, situated near the margin, is a little depression which Turpin has called the MICROPYLE, which is, according to him, the trace of the place where the branch of the pistillary cord entered; the other,

which the same naturalist names OMPHALODE, and which occupies almost all the rest of the hilum, is slightly convex in the centre, and appears to be the trace of the cicatrice of the nourishing cord.

When the embryo is directed towards the hilum, the vessels go directly from it to the chalaza, which is then confounded with the hilum; but when the embryo is directed in the contrary way, the chalaza is very distinct from the hilum, and the umbilical cord is prolonged through the mesosperm from the hilum to the chalaza; this course of the fibres is called the RAPHE, and appears externally as a kind of little nerve. The umbilical cord is a prolongation of the carpellary fibre, which bears the seed, and is itself prolonged into the raphe; the chalaza is the true hilum, that is to say, the point where the embryo draws its nourishment from the mother plant; but it is often difficult to determine its position, both on account of its small size, and of the change of position of the embryo during the growth of the seed.

There are some Monocotyledonous seeds, in which the radicle causes by its position a little projection on a given part of the spermoderm; and at the period of germination it shoots out from this part; it is doubtful whether it be an organ properly so called, seeing the small number of plants in which it is found.

SECTION III.

Of the Albumen.

If we examine an ovule at the period of flowering, we find its spermoderm already well-formed, and its cavity filled with a mucilaginous fluid, to which the

name of AMNIOS is given. This liquid is, or may be, transmitted into the cavity of the seed by the umbilical cord, or more probably is secreted by the endopleura.

As soon as fecundation has taken place, the embryo, which swims in the amnios, begins to be developed; it occupies more space, and the amnios consequently diminishes; it is probably absorbed by the embryo, to which it may serve for nourishment, or it may be reabsorbed by the neighbouring organs: whatever becomes of it, it happens after a certain time, that, in some plants, the whole of it disappears, and the embryo alone occupies the cavity; in others, the more fluid part of it alone disappears, but its solid particles are deposited, and solidify into a particular body, to which many different names have been given, but I prefer that of ALBUMEN, both because it makes allusion to the albumen of eggs, and because the name is applicable to this substance in its being of a white colour in all seeds.

The albumen is less an organ, properly so called. than the residue of one, or a deposit formed in cellular tissue; it does not present, at least at the maturity of the seed, any organic connexions either with the endopleura or embryo; we do not perceive in it any vascular organization, but only a mass composed of cellular tissue, and not adhering to any of the neighbouring organs: if this be not the case perhaps in some of the Coniferæ and Cycadeæ, where there is a slight adhesion between it and the radicle. What has often induced persons to speak of the albumen adhering to the spermoderm, is, that several naturalists have described as albumen, the endopleura when it is thick and fleshy; it is this that happens in those Leguminosæ in which the existence of albumen has been admitted. The seed in which the nature of this body can be followed with the greatest facility is the immense one of the Cocoa-Nut

Palm, of which the albumen occupies so large a portion. The Cocoa-Nut, in its young state, is filled with a watery fluid, which soon becomes of the consistence of an emulsion, and then takes the name of milk; it is at this period that it is made use of as a beverage; soon, the solid part suspended in the emulsion is deposited, and concretes upon the walls of the seed in a state which does not bear a bad resemblance, in consistence, to our Almonds, and which is edible as they are. Finally, this amygdalaceous deposit hardens and forms an albumen with a slightly oily flesh which lines the walls of the seed; the centre, at first occupied by a watery fluid, is converted into an empty cavity by the evaporation and absorption of this water. What I have described in the Cocoa-Nut, takes place in all other seeds where albumen is formed, except that this substance usually fills the whole cavity without leaving any space, and its size, form, nature, and position vary in different plants.

In a seed of a given size, the volume of the albumen is essentially in an inverse ratio to that of the embryo. The families in which the albumen is larger in proportion than the embryo, are the Palmæ, Liliaceæ and neighbouring families, Euphorbiaceæ, Nyctagineæ, Rubiaceæ, Umbelliferæ, Ranunculaceæ, &c.; it is met with, but in much less proportion, in the Convolvulaceæ, Violarieæ, &c.; it exists only in certain genera in the Labiatæ; lastly, it is completely wanting in the Cruciferæ, Leguminosæ, Compositæ, &c. The families which have no albumen, have the embryo large; in those furnished with it, the embryo is sometimes of extraordinary minuteness; thus, in Ranunculaceæ and Umbelliferæ, it frequently presents only a small niche in the albumen, near the base of the seed. In general, we must remark that it is hardly ever absent in any family of Monocotyledons; the Alismaceæ alone appear devoid of it, whilst

its entire absence is frequent in Dicotyledons; of the families of this class, about a third are constantly devoid of it.

The nature of the albumen presents great variety in the different families, and a remarkable constancy in each of them.

1st. One of its most ordinary states is that of being fleshy, as is seen in the Cinchonaceæ. This fleshy state degenerates into a firm and almost woody texture in some families, as in the Umbelliferæ.

2d. It is often oily, as is seen in several Palms, and especially in the Euphorbiaceæ, in which we remark that their embryo is also impregnated with oil, but that the nature of these two fixed oils is different; that of the embryo is acrid, as is the entire plant, of which the embryo is a miniature representation; that of the albumen, which is a particular secretion of an organ, is in general bland and wholesome, although more or less laxative.

3d. It is frequently feculent or farinaceous, as is observed in the Caryophylleæ, Nyctagineæ, and especially in the Gramineæ; for it is the albumen of the Cereal Gramineæ which serves for the principal nourishment of the human species.

4th. We find horny albumens, such as that of the Asparageæ, the Coffeaceæ, &c.

All known albumens are of a wholesome nature, to whatever family they belong; those of the Euphorbiaceæ are laxative; their properties are also similar in all those which have an analogous consistence. Thus, all farinaceous albumens are sensibly of the same nature; the farinaceous albumen of the Polygoneæ, for example, may be substituted for that of the Gramineæ: all horny ones present some analogy with that of the Coffee; thus those of *Galium* and Ruscus, when roasted, have the odour of Coffee.

The general form of the albumen is moulded upon the inner cavity of the endopleura, and is modified by that of the embryo. In general, it is all in one mass; but there are some genera of the Rubiaceæ, such as *Rutidea* and *Grumilea*, where it is presented under the appearance of little portions detached from one another. It presents in some plants, and especially in all the Anonaceæ, a character which is very remarkable, viz.—the endopleura is wrinkled or prolonged into projecting laminæ, so that when the albumen is cut lengthways, it seems furnished upon its margins with little transverse lamellæ, a very remarkable character which Mr. Robert Brown has met with in the anomalous genus *Eupomatia*, which he discovered in New Holland.

The position of the albumen is always in the empty space left by the embryo, which is in general more or less central, and then the albumen surrounds every part of it; the embryo is sometimes lateral, or situated at the base near the chalaza, and then the albumen occupies the rest of the cavity, as in *Portulaca*, the Marvel of Peru, &c.: lastly, when the embryo is peripherical, then the albumen is found in the centre, as, for example, in several Polygoneæ and Chenopodeæ. There are seeds among the Malvaceæ and Bombaceæ, in which the albumen is reduced to a small farinaceous deposit, lying between the cotyledons.

The use of the albumen has not yet been perfectly studied; it is evident that the amnios, especially when it is absorbed, must serve to nourish the embryo, and that the albumen must serve to nourish the young plant at the period of germination. We see, in fact, that most, if not all albumens are transformed at this period, by the addition of the water which they absorb, into an emulsion-like matter, which is absorbed by the embryo, and serves to develop it; but the details of this phenomenon have

not been sufficiently observed, and I ought the more to abstain from mentioning them here, since they belong entirely to Physiology.

Section IV.

Of the Embryo.

The Embryo is the object and end of the whole function of sexual reproduction. It is a young plant in miniature, already provided with every organ essential for nutrition,—with a root, which at this age bears the name of Radicle: with a stem, which receives from analogy the name of Cauliculus, or more usually that of Plumule; and lastly, with leaves themselves, to which, seeing that their appearance differs much from others, the name of Cotyledons has been given. Let us examine the embryo at its three ages—1st, whilst it is in the state of an unfecundated germ; 2d, during its state of torpor in the fecundated seed; and 3d, during the changes it receives by the act of germination.

The first of these articles will be short; for the embryo is hardly visible before fecundation: as soon as it can be perceived it appears very small, floating in the water of the amnios. It is possible that the radicle draws its nourishment, either from the hilum or from the amnios, without having any organic connexion with either, and by simple absorption, analogous to that by which the roots draw the nourishing fluids from the earth. It is possible that at this period of its life, the extremity of the radicle communicates by a vascular filament with the umbilical cord, and by this filament it may receive its fecundation and nourishment; but it has

not as yet been seen by anatomists in a positive manner; if it exist, it is probably destroyed before maturity. Is not the filament which has been seen by Richard going from the hilum to the radicle in the Cycadeæ and Coniferæ, that of which I have been speaking, which in these families may be more persistent than in others?

When the embryo has not been fecundated, or when, having been so, some particular cause has arrested its development, we may suppose two cases possible—either the whole ovule may become abortive on account of the abortion of the embryo, and then the seed is wanting in the place where it ought to be found; this is most frequently the case; or the integuments of the seed may continue to be developed, so that the seed appears perfectly formed externally, but internally it is found empty: when it has albumen, this is often formed then as usual; but the place of the embryo is vacant. Thus it is not rare to find seeds of the Coffee well-formed as to the spermoderm and albumen, but having the cavity of the embryo empty. There are some cases in which it is difficult to affirm which of these abortions has taken place; thus, for example, if we examine the fruit of *Ranunculus lacerus*, a hybrid plant, we shall find the seeds well-formed externally, but empty within; is it the seed which is abortive in the carpel, or the embryo in the seed? In this particular case I believe that the seed is entirely abortive, because the albumen is absent; but if it took place in a plant without albumen the question would be insoluble; this happens in *Centaurea hybrida*, the achenia of which are empty, without our being able to affirm whether the spermoderm exists or not.

The fecundated embryo generally grows very rapidly; the water of the amnios gradually disappears, either wholly, or, its fluid parts being absorbed, the solid residue concretes into albumen. In the first case, the seed

or embryo is said to be EXALBUMINOUS, and the embryo is sometimes called NAKED or EPISPERMIC; in the contrary case, the seed or embryo is said to be ALBUMINOUS or ENDOSPERMIC. It must be observed that the word Perispermic signifies, in the nomenclature of Jussieu, that there is albumen, and in that of Richard, that there is none; an example which, in the midst of numbers of others, proves the inconvenience of changes of names.

When the radicle is directed towards the hilum, which, as we know, is the base of the seed, we say that the embryo is ERECT, or that the radicle is INFERIOR, or directed to the base; when it does not point to the hilum, it may be either lateral as in the Coffee, or directed upwards, it is then SUPERIOR, and the embryo INVERTED, as in the Doom-Palm; this is the only exact sense in which the position of the embryo can be designated. But carpologists have often extended these terms in another sense; they have frequently referred the direction of the embryo, not to the seed, but to the fruit; so that when a seed is pendent in the fruit, all the terms which designate the position of the embryo must be generally taken in a contrary sense.

Whether the embryo be inferior or superior, it may be erect, curved, or folded upon itself. In the first case, if it be long, it occupies the axis of the seed, and is named AXILE, as in *Spondias*, *Empetrum*, &c.; if it be short, it only occupies a small portion of the axis; and it is said to be BASAL if at the base, as in *Ranunculus;* and APICILAR if at the apex, as in *Clematis.* Similar differences take place in curved ones; they are usually lateral, and situated at the side of the seed; if they be equal in length to it, or shorter, they proceed from their origin to the other extremity, and are then said to be CURVED, as in different species of *Polygonum;* if their

length exceeds that of the seed, they return by the other side toward the base, and are then termed PERIPHERICAL, as in the Spinach; if they be still longer, they may describe one and a half, two, or three turns, and are then called SPIRAL, as in *Dodonæa*. As to those which are folded upon themselves, I cannot explain their structure before having spoken of the parts of the embryo.

The RADICLE (*radicula*) is that part which represents the root; in most Dicotyledons, it is presented in a conical form, very like that of ordinary roots; it goes on gradually tapering from the neck to its extremity, which is pointed; at the period of germination it elongates by its extremity, as other roots do during the whole course of their lives, and makes lateral shoots, but very slowly. To plants thus organized Richard has given the name of EXORHIZEÆ, because their radicle is, as it were, projecting and developed: on the contrary, in all Monocotyledons and some Dicotyledons, as *Berberis*, *Nuphar*, &c., the radicle is thick and rounded at the extremity; it scarcely elongates at the period of germination, but gives origin, either laterally, or from its apex, to some usually simple little roots, which act the part of radicles, and sometimes seem to issue out of the round radicle by particular slits; this structure has caused Richard to give to plants, thus organized, the name of ENDORHIZEÆ. This has been for a long time observed in Wheat, Rye, and Barley, and more attentive observation has proved that a great number of other plants partake of the same structure.

It frequently happens in the embryos of the Endorhizeæ, either that the radicle, from which the little roots ought to proceed, is very thick, and, as it were, capitate, and then the embryo is said to be MACROPODOUS, as in *Pekea;* or, that one of the lateral parts

of the radicle takes some unusual development, and then this kind of tubercule has been confounded with several others under the name of VITELLUS; or that the radicular extremity, being arrested in its elongation, becomes reflected upon itself, and forms a kind of perfectly close sac, which surrounds all the embryo, this has received the name of SACCULE, and is seen in the Nymphæaceæ. Thus, this distinction of plants into Exorhizeæ and Endorhizeæ, which would seem to promise a new confirmation of the natural division of the two great classes of Phanerogameæ, is found reduced to a remarkable phenomenon it is true, but which cannot serve for the purposes of classification.

When at the germination of the Exorhizeæ we cut the extremity of the radicle at the moment it protrudes from the seed, it is transformed, as it were, artificially into an endorhizeous one; that is to say, we oblige it to produce lateral radicles, much more than it was naturally intended to do. The distinction of Exorhizeæ and Endorhizeæ, which seems so decided at first sight, becomes less pronounced when we examine the intermediate cases; thus, the common Radish presents below the neck two laminæ applied upon the root, which are kinds of Coleorhizæ, for they are the remains of a kind of sheath which the radish has pierced through or torn, so then we might say that the Radish is an Endorhizeous plant, which shoots out but one radicle.

Radicles, whatever be their form, are often furnished at the moment of their development with particular hairs which are of a silvery-white colour, long, bristly, but of a very soft texture, and short duration; they arise principally from near the neck, and always in the parts exposed to the air; their particular use is not yet well known, but their existence is especially remarkable

in the roots being in general devoid of true hairs, to which, in order to designate their situation, I have given the name of Radical Hairs.—(Book i. ch. 10, sect. 7.)

The radicle of the embryo, whatever be its form, is perceived—1st, in the seed before germination, because it is always directed outwards—a very important character to observe in Monocotyledonous plants, where it is sometimes the only one by which we can readily distinguish the two extremities of the embryo ; 2d, after germination ; because, with a very small number of exceptions, as the Misletoe, the radicle is directed towards the centre of the earth. This direction is so decided that it presents itself under the most different circumstances. We observe in particular, that whatever be the position of the germinating seeds, the radicle is always directed downwards, and if one more or less developed be turned to the zenith, it always tends to return of itself, so as to resume its natural position. The cause of this phenomenon is an object of delicate physiology, which will be discussed elsewhere ; I only mention the fact here, as a distinctive character of germinating radicles.

The Plumule (*plumula*) is, as we have said, the stem of the embryo or young plant, already present in the seed or at germination ; it is distinguished, whatever be its form, by characters opposite to the preceding, viz. because in the seed it is directed inwards ; at germination, because it has a tendency to rise towards the zenith, becoming green when exposed to the light, and presenting all the other characters of stems. It may be divided into two parts, which Richard has called the cauliculus and the gemmule.

The Cauliculus is that part of the plumule which is between the neck and the cotyledons ; the Gemmule (*gemmula*) that which is above the cotyledons ; in

embryos which have no apparent cotyledons, as the Dodder, these parts are confounded.

The existence of the cauliculus has often been denied, because this organ is sometimes so short, as to be scarcely distinguishable; but as the cotyledons always spring from the stem, the great or small distance from their point of origin to the neck, can always be perceived. This length of the cauliculus also appears to be of little importance in the symmetry of the young plant; thus, in the Papillionaceæ, the French-bean presents it nearly two inches long, and in the Pea, it is so short as to be hardly visible. Its length influences, at the period of germination, the situation of the cotyledons—whether they be elevated above ground, or on a level with the surface or subterranean; these three manners are met with in the Leguminosæ, and the example is of itself sufficient, independently of all other reasoning, to prove that we cannot derive the primary divisions of plants from these characters, as Willdenow has proposed. The cauliculus is always simple, even in plants which become the most branched; almost always devoid of leaves, even when they are very numerous near the root; the branches and leaves only begin to be developed above the cotyledons. I only know one exception to these rules—*Euphorbia*, which has sometimes buds upon the cauliculus below the cotyledons.

The existence of the cauliculus, which is so evident at germination, tends to prove that we ought not, as some naturalists have done, to confound the neck, properly so called, *i. e.* the plane of separation between the root and stem, with the point of origin of the cotyledons. These two points in the French bean are nearly two inches apart, and never exactly coincide.

The gemmule, or the part of the stem which is elevated above the cotyledons, is truly the first bud of the

plant; there are seeds where it is presented under the appearance of a little sharp point, hardly visible; there are others where it already has small leaves visible, to which the name of PRIMORDIAL LEAVES is given. In general, the gemmule, on developing at the period of germination, presents all the appearances of a young branch which proceeds from a bud furnished with leaves. In some cases, such as *Cactus Melocactus*, *Euphorbia Canariensis*, and in general, in succulent plants with very small leaves, it is very thick, fleshy, round, and devoid of leaves: in this case it has sometimes been taken for a single cotyledon; but on observing it more closely, we find the two cotyledons very small it is true, and, as it were, concealed in the mass of the gemmule. Embryos, with this kind of gemmule, have received the name of MACROCEPHALOUS ones.

The name of COTYLEDONS, as we have said above, is given to the first leaves of the plant already formed, and visible in the seed. That they are leaves is easily proved:

1st. By their usual transformation into leaves, and becoming green at germination.

2d. By their respective position, similar, or analogous to that of the plant already developed.

3d. By their structure, exactly resembling that of leaves; and because they are generally furnished with vessels, and stomata distributed in the same manner.

4th. Because, in plants where the leaves present peculiar phenomena, such as the mobility of those of the Sensitive-plant, or the presence of glands in those of *Hypericum*, or *Gossypium*, (Pl. 23, fig. 1), &c., the cotyledons present the same characters.

5th. Because their development, death, and fall, are analogous to what takes place in ordinary leaves.

6th. Because the cotyledons are absent in plants devoid of leaves, as *Cuscuta*.

7th. Because, when they are opposite they bear in their axils as opposite leaves, sometimes a single terminal gemmule, at other times, three small ones; a central one, which is the prolongation of the cauliculus, and two axillary ones.

8th. Finally, because the analogy of the radicle to the root, and of the plumule to the stem, having been proved, that of the cotyledon to the leaves, is an evident consequence.

The principal difference that plants present, as to their cotyledons, results from the respective position of those organs which are distributed in two manners: the first takes place when two or more are situated upon the same horizontal plane, and then they are opposite or verticillate; as the first case is by far the most frequent, we give to the whole class of plants, with two or more cotyledons, the name of DICOTYLEDONS. When it is necessary to express positively, that the cotyledons are verticillate, we call the plants POLYCOTYLEDONS, but they cannot be considered as a class. In fact, 1st very similar plants present both these manners; thus, *Pinus* (Pl. 23, fig. 2) and *Abies* among the Coniferæ are polycotyledonous, and the other genera of the family dicotyledonous; 2d. also in polycotyledonous genera or species, the number of cotyledons is not regular; 3d. in several, they are disposed in two opposite parcels, which seem to refer to the primitive type of the class; 4th. in all verticillate cotyledons, as in all, or nearly all verticillate leaves, we only find two opposite buds, besides the central prolongation of the stem; 5th, some species with two cotyledons accidentally present three or four, as I have seen in the French bean, *Ranunculus*, and Cabbage; 6th, lastly, I have above said (Book II. chap. iii. sect. 7,) that the distinction between opposite and verticillate leaves is very uncertain;

therefore it is with just reason that all plants with opposite or verticillate cotyledons have been classed together: perhaps a more applicable name than that of Dicotyledons might have been given to them; but it must be observed that it is not the number which is essential, but their respective position. Although I do not attach, as one sees, as great importance to the number as the term Dicotyledon would lead one to believe, I ought to notice, however, notwithstanding what has been said, that I have never seen *Ranunculus, Fumaria, &c.* germinate with one cotyledon, the binary number peculiar to the class being always met with.

The second system of arrangement of the cotyledons is, that where the leaves being naturally and essentially alternate, the lower one or cotyledon is solitary, and consequently lateral. The plants or embryos in which this disposition takes place, bear the name of MONOCOTYLEDONS; this term is more correct, in general, than the preceding, but still anomalies are met with here and there. In most monocotyledonous embryos the cotyledon or lower leaf is alone so large and developed as to be visible in the seed; but it frequently happens that along the gemmule we observe other little bodies analogous to the cotyledons, and situated alternately: these are, properly speaking, primordial leaves; if this name be given to them, the plant might be said, in a strict sense, to be monocotyledonous; but if they be called secondary cotyledons, which their appearance and nature might authorize, it must then be said that they are Monocotyledons with two or more alternate cotyledons; thus here also it is the position and not the number which serves for the character of classification. *Cycas* is the only really doubtful case which may be mentioned as tending to impair the separation of the two great classes of Vasculares; we here find two cotyledons more

or less unequal, but they are not strictly opposite, the smaller one arises a little above the larger, and, consequently, the embryo, although having two cotyledons, belongs to the class of Monocotyledons, which confirms the whole structure of the stem and fructifying apparatus.

We call those plants ACOTYLEDONS, which are devoid of cotyledons; but under this name one may comprehend two very different organizations;—1st, The NEMEA of Fries, or cellular plants, which are all considered as Acotyledons, although in most the germination is ill understood;—2d, Among vascular plants, those which are devoid of cotyledons, and which Fries names exclusively ACOTYLEDONS, are generally also devoid of leaves: such are *Cuscuta*, and *Orobanche*, which, notwithstanding, we are obliged to class among Dicotyledons, and perhaps some leafless Orchideæ, which do not less belong to Monocotyledons. The only known example of a vascular plant furnished with leaves, and apparently devoid of cotyledons, is *Lecythis*, the singular germination of which Du Petit Thouars has described. We must consider this seed as formed of two fleshy cotyledons, united with each other and with the plumule, and which do not separate at germination. In several succulent plants the cotyledons are so small, as in *Cactus Melocactus*, &c. (Pl. 23, fig. 3,) or so adherent to the cauliculus, as in *Stapelia*, that we might think them absent, from a superficial observation.

Next to their position, that which most distinguishes cotyledons from each other, and which causes the greatest difference in their history, is the presence or absence of stomata, which is always connected with their texture. All those which, when developed, present stomata on their surface, are more or less foliaceous, and of a

green colour; they then take the exclusive name of SEMINAL LEAVES.

All those which have no stomata, remain in a fleshy or farinaceous state, and do not become green; these are usually only called fleshy cotyledons.

Foliaceous ones are very frequent among Dicotyledons, and are hardly ever found in Monocotyledons, but they exist in Ferns. Fleshy ones are common in Monocotyledons; they are also met with among the Dicotyledons in the tribes Phaseoleæ, Viciæ, &c. of the Leguminosæ, in Hippocastaneæ, *Trapa*, the Chestnut, &c.; foliaceous cotyledons are, in general, more frequent in albuminous Dicotyledons; and fleshy ones in those which are exalbuminous; the reverse would seem to occur in Monocotyledons.

Foliaceous cotyledons being furnished with stomata, can, from the moment they are exposed to the air, elaborate the sap which is transmitted to them by the radicle, and, consequently, it is not necessary that they should be provided with a store of nutriment prepared beforehand for the young plant; fleshy ones, having no stomata, cannot elaborate the sap, and there would be no action if they were not filled with a quantity of fecula or mucilage, which, diluted by the water absorbed by the radicle, is thus transformed into nourishment. We may say, then, that the cotyledons nourish the young plant, when they are foliaceous by elaborating the sap in the same manner as leaves, and when they are fleshy by furnishing nutriment prepared beforehand, as in the albumen or tubercules; whence it results that every organ which has no stomata, and is not fleshy or filled with fecula, is not a cotyledon, an important character which, in certain doubtful cases, elucidates the nature of organs; for example, it has enabled me to deter-

mine the character of different parts of the seed of *Nuphar*.

It must be observed, that as germination has most frequently been studied in the French-bean, Wheat, and other plants with fleshy cotyledons, that which is only true as regards this class, has, in general, been too readily extended to all.

Foliaceous cotyledons are, on account of their nature, always destined to come out of their envelope, and also above ground, at germination; but it is not the same with fleshy ones; the first come out of their integuments as the French-bean, the second continue in them, and remain under ground, such as the Pea, Vetch, Horse-chestnut, &c. As most monocotyledons have the cotyledon fleshy, it is conformable to analogy that it should be subterranean, which in reality is the case.

A curious consequence which results from the nature of the two kinds of cotyledons which I have mentioned, is, that the fleshy ones alone are those which man makes use of for food; he takes for his own use the deposit of nourishment which the mother-plant had prepared for its offspring, in the same manner as in the eggs of birds: it is thus that the seeds of the Leguminosæ with fleshy cotyledons, such as Beans, Peas, Lentils, *Cajanus*, &c. serve for the food of man, whilst those with foliaceous ones are useless or dangerous. There are no apparent exceptions to this rule but in albuminous seeds: it is then the albumen, which is itself a deposit of nourishment, that man makes use of; thus Buckwheat *(Polygonum)* is edible on account of its farinaceous albumen; the Gramineæ have at the same time a fleshy cotyledon and farinaceous albumen, a double circumstance which contributes to place them in the first rank among nutritive seeds.

The forms of foliaceous cotyledons are as variable as

those of leaves; most, however, are entire: but some are lobed either at the apex, as in *Helicteres, Convolvulus,* the Radish, &c., or at the base, as in *Polygonum,* &c.; some are divided, being palmate, as in the Lime-tree, or pinnatifid as in the *Erodium Pimpinellifolium.* But the principal difference which they present in this respect consists in the lateral cotyledons of phanerogamous Monocotyledons being almost all sheathing at the base, whilst this form is rare in Dicotyledons; this corresponds very well with the ordinary form of the leaves of the two classes.

Among Dicotyledons, it happens from time to time that the two cotyledons are found united; this union takes place laterally, unequally, and purely accidentally, in a great number of plants—for example, in *Ebenus Cretica* or *Tithonia;* it is constant and regular, in some united at the base, so that they seem to form a kind of disc pierced by the stem, as is seen in several Ficoids.

Fleshy cotyledons are generally of a more irregular form, and frequently united together by their whole inner surface; this is seen in the seeds of the Horse-chestnut, Nasturtium, *Eugenia,* &c., which at first sight might appear Monocotyledons, because their two cotyledons are united into a single mass.

The inequality of the cotyledons, which is rare and entirely accidental in Dicotyledons, where they are foliaceous, is not very rare in those where these organs are fleshy; the seeds which I have mentioned present good examples: but in this respect the seed of *Trapa* deserves mention. In *Trapa natans,* which is so well known in Europe under the name of Water-chestnut, the two cotyledons are extraordinarily disproportionate; they are exactly opposite, as in all Dicotyledons, but one is so small, that it must be carefully sought for before it can be perceived, and it comes out without difficulty with

the rest of the embryo, by a small circular hole, from the envelope formed by the spermoderm invested with the pericarp and calyx; the other is very large, farinaceous, borne upon a long petiole, and remaining in the spermoderm, the whole of which it fills; the first, which is rudimentary, is almost useless, and does not furnish any nourishment; the second provides the radicle with all the nourishment which serves for its development; whence it results that the side of the root which corresponds to the great cotyledon increases much, and gives rise to a great number of little roots; whilst the opposite side, which corresponds to the small cotyledon, does not produce any little roots, and, as it remains very short, draws towards it the whole body of the root.

The cotyledons, considered as to the manner in which they are folded or rolled up in the seed, present as many varieties as leaves in the bud; considered as to the position of the radicle, they are sometimes continuous with it, as in erect embryos, and sometimes curved or folded upon it,—a character which is more frequently, but perhaps less correctly expressed, by saying that the radicle is curved or folded upon the lobes. Dicotyledons present two very evident varieties among folded embryos; thus, sometimes the radicle is folded back upon the cotyledons, so as to lie in the fissure between them; this is seen in all the Papilionaceous Leguminosæ and Cruciferæ Pleurorhizeæ; in this case we say that the radicle is LATERAL, which is indicated by the sign o=; or the radicle is folded upon the back of one of the cotyledons, and it is then said to be DORSAL, which is expressed by the sign o||: this is seen in the Cruciferæ Notorhizeæ.

If we consider the respective position of the cotyledons themselves, we shall find several varieties:—

1st. The greatest number of plants present the cotyledons absolutely flat, that is to say, without any curve or folding; such are those of *Cytisus, Ricinus, Arabis,* &c.; this form is compatible with every position of the radicle.

2d. There are some which are folded longitudinally upon their middle nerve; these always have the radicle dorsal; such are, for example, the Cruciferæ Orthoploceæ; these cotyledons are said to be CONDUPLICATE, and are designated by the sign o≫.

3d. There are some curved or rolled spirally, in a longitudinal direction, as, for example, those of the Combretaceæ—*Punica, Helicteres,* &c.

4th. Some are bent double, as in the Cruciferæ Diplicolobiæ, such as *Heliophila.*

5th. We find cotyledons flat, but rolled crossways one upon the other, as, for example, in the Cruciferæ Spirolobeæ, such as *Bunias.*

6th. Lastly, there are some which are irregularly plaited or crumpled upon one another; such are those of the Mullow.

This kind of character does not appear connected in an intimate manner with the symmetry of plants, since there are families where we find united several of these different foldings of the cotyledons; the Cruciferæ, in particular, present five different systems.

As leaves, some cotyledons are furnished with petioles, others are sessile; the former, as well as several of the latter are, as it were, articulated at the base, and fall off soon after germination; there are, however, annual plants, where they remain until the flowering, as some species of *Veronica* and *Galium,* &c. Sheathing cotyledons, or even simply sessile ones, are more permanent, or only destroyed in part. Those of several succulent plants are particularly remarkable for their permanence;

thus, *Euphorbia Canariensis* still presents remains of them at the end of one, or even two years.

We have not as yet any certain proof of cotyledons furnished with stipules, if this do not happen in *Trapa natans*, where the ascending twin filaments, which are observed near the base of the stem as far as the origin of the cotyledons, appear to be true stipules.

The primordial leaves which we see sometimes fully developed in the seed with the cotyledons, as in the French-bean, or which are developed immediately after them, are always of an analogous nature to the true leaves of the plant; but they often differ—1st, in form; thus, those of the French-bean are simple and heart-shaped, instead of being trifoliate with oval leaflets; the difference, however, rarely proceeds as far as this; 2dly, in size, which is usually less; 3dly, in position, which, in Dicotyledons, is opposite, or nearly so, even in species where the leaves become alternate as the plant advances in age; sometimes the change takes place suddenly, as in the French-bean, which has the first two leaves opposite, and all the others alternate; at other times gradually, so as to show that the alternate position is a simple degeneration, owing to the mode of development. The contrary takes place in Monocotyledons, which have their leaves alternate. It results from this, that when we see a plant with the lower leaves opposite, we may be pretty certain that it belongs to Dicotyledons; and if we find one with them alternate, there is great probability that it is a Monocotyledon.

CHAPTER V.

OF THE ORGANS OF REPRODUCTION WITHOUT FECUNDATION IN PHANEROGAMOUS PLANTS.

I SAID, on commencing to treat of the organs of reproduction, that all organized beings appeared to be reproduced by the development of pre-existing germs. Are these germs, as Bonnet maintains, bodies existing in infinite numbers from the commencement of the species, inserted into one another and destined to be successively developed under favourable circumstances? Or, are they productions successively formed by vital action, or, as has been said, by the plastic forces of individuals, so as to pre-exist only a short and definite time before the period when their development is visible? It is hardly necessary to discuss this question as regards the subject upon which we are at present engaged. It will be sufficient to admit that there exist in different parts of plants, germs which are developed after two manners: one kind requires the particular act of fecundation, and forms the seeds of which we have been examining the structure, &c.; the other kind, in order to be developed, only requires the concurrence of certain circumstances purely relating to nutrition.

Among these last, there are some, which, without any preparatory apparatus, are developed when the nourishment becomes more abundant in a given place;

this phenomenon is purely physiological, and can hardly be placed in Organography; thus, when we make a notch in the bark of a tree, a swelling, that is to say a deposit of juices, is caused there by the stagnation of the sap, and the latent germs are developed with facility at this point; this fact is only connected with Organography in these respects :—

1st. That every species presents fixed points where certain developments of germs readily take place.

2d. That certain species present particular points where there is naturally a stagnation of the juices and a deposit of nourishment, and where, consequently, the germs are already visible in the natural state or more easily developed.

As to the first respect, we remark that the axils of the leaves are the principal of these fixed points in all plants where, by the ordinary progress of vegetation, there is facility for the development of the germs of branches: this is what happens in the natural course of things, forming ordinary buds.

As to the second, there are plants which present naturally, here and there, articulations or transverse swellings, which retain the sap, form deposits of nourishment, and consequently favour the development of germs; such are the articulations of Pinks, Vines, and Geraniums, the nodes of the Gramineæ, &c. There are others which form, here and there, kinds of exostoses or tubercules filled with a quantity of fecula, and which have a tendency to cause the germs situated upon their surface to be developed; such are Potatoes, &c.: the germs appear upon these tubercules as opaque slightly fleshy points, to which the name of Eyes is frequently given. Every one knows, at least from the popular example of the Potatoe, that these eyes or germs, when separated from the feculent part of the tubercule and

placed in favourable circumstances, can develope and produce a new individual; but we also know that this development is more ready and vigorous, when we leave around each the whole or part at least of the nourishment which had been previously collected for it. Thus, developments of this kind are favoured by the nourishment accumulated in the tubercules, but may take place by the forces peculiar to the germ which attracts the surrounding water. There are, in fact, other tubercules where we find the germ furnished with a very slight provision of nourishment; such are those which arise from the roots of *Saxifraga granulata*, and the little bulbs which are accidentally or constantly developed in the axils of the leaves of several Liliaceæ, and even in the axils of their spathes, and which may indifferently be considered either as buds or tubercules.

There are cases where the germs exist almost without any provision, appearing under the form of dots, but ready to be developed under favourable circumstances; such are the points visible in the notches of the leaf of *Bryophyllum Calycinum*, and which are developed when this leaf, having become old, happens to touch the moist earth.

When the tubercules, which bear germs, become detached from the plant which has given birth to them, we can easily imagine that the double circumstance of their being isolated bodies, closed on every part, and capable of producing a new individual when sown, has caused them to be taken for seeds; this happens in *Ficaria*, for example, where the development of these bulbs has been described as a true germination.

This error is the more excusable, as there are cases where it is really difficult to elucidate the truth, and where we observe remarkable affinities between seeds and tubercules.

Thus, we find several species of *Crinum* and *Amaryllis,* in which the cells of the fruit, instead of enclosing seeds in the usual state, each contain only a thick, round, fleshy body, on which we remark a small eye; this body is detached from the pericarp at maturity, and when sown produces a new individual. Is this a tubercule or bulb, as it is generally said to be? Is it a seed, modified in texture, as some modern botanists think? In order to embrace with any confidence either of these opinions, we must first of all know what essential difference is found between seeds and tubercules. Cannot the same germ, according to the state of its developments, either require fecundation, which is the ordinary case, or not require it, and then be developed under the form of a tubercule or bulb? This supposition seems to acquire some weight if we reflect that the germs of *Bryophyllum* are placed in the leaf precisely as the ovules in the pericarp, and, consequently, appear to be of the same nature. A second example, as curious though less clear, is presented to us in *Lemna;* the ordinary mode of reproduction in this plant, is the development of a lateral germ situated upon the margin of the foliaceous disc which composes the whole plant; this germ, on developing, forms a second foliaceous disc, united to the first, but which afterwards separates and forms an entire plant. When these plants happen to flower, which is very rarely the case, the flowers are found precisely in the same point where the germ usually is; whence we may suppose that this germ can be developed, according to circumstances, with or without fecundation.

Lastly, we shall see in the following Chapter, that there are Cryptogamous plants, in which it is perfectly impossible to affirm whether their development results from a true fecundation, or from circumstances purely

regarding the nutrition. If the identity of nature of these germs, developed with and without fecundation, could be completely demonstrated, it would be a powerful argument against the system of EPIGENESIS. I must explain myself:—among the naturalists who have studied the theory of animal generation, there are formed two opposite classes:—some, such as Haller, Bonnet, and Spallanzani, maintain that the germ exists perfectly formed, before fecundation, in the female organ, and only receives from the male organ its vital action. The others, as Needham, &c., have thought that the germ exists in the male organ, which transmits it to the female, which only serves as a matrix for it. The recent observations of Prévost and Dumas seem to give force to this last opinion, although, in fact, all that is known can be explained in both theories. When we wish to apply these considerations to the vegetable kingdom, we are asked if the little granules, which are perceived in some fovillas, do not enjoy an analogous function to what is attributed to the spermatic animalculæ; but notwithstanding the numberless facts which prove the existence of the ovules before fecundation, and the continuity of the embryo with the mother-plant, it is evident that if the unfecundated germs are developed in the same manner as fecundated ovules, we must conclude that they are produced by the female organ, and only owe their vital action to the male.

The reproduction of plants by simple division, or, which is to say the same thing, by unfecundated germs, is an universal phenomenon, and all plants appear capable of this mode of multiplication. Vegetable fecundation, some philosophers have said, is a useless phenomenon, since all plants have another mode of reproduction, and consequently, we ought not to admit it. We may respond to this kind of argument:—1st,

that the fecundations of animals capable of division must also be denied, whilst there are several where the two modes of reproduction are very certain; 2d, that it is very true that all plants can be reproduced without fecundation, but in most it requires the hand of man to cause this phenomenon; that therefore all phanerogamous plants, which are not either creeping, rooting, or furnished with tubercules, *i. e.* three-fourths of all known plants, would be deprived of all natural reproduction, if the germs of their flowers were not vivified by fecundation.

It remains then from this observation, that reproduction by unfecundated germs is common to the whole vegetable kingdom, a very remarkable circumstance when compared with the animal kingdom; but that this form of reproduction requires a concurrence of physiological circumstances which are rarely found in the state of nature, and that fecundation is the natural form which replaces it, and thus insures the perpetuation of the species.

CHAPTER VI.

OF THE ORGANS OF REPRODUCTION IN CRYPTOGAMOUS PLANTS.

Section I.

General Considerations.

As soon as we began to study with any care the structure of the flower and fruit of plants, we immediately divided them into two great classes:—Phanero-

gamous ones, of which we have been speaking, and Cryptogamous ones, which we are about to study in this Chapter.

Some naturalists, struck with the extreme difference of these two classes, and believing that all plants, which did not present a flower formed as in ordinary ones, had really no flower, but were reproduced by simple unfecundated germs, have given collectively to these plants the names of AGAMÆ or INEMBRYONEÆ; others, struck with the fact that their reproductive bodies were formed without apparent cotyledons, have designated them by the name of ACOTYLEDONS. Some, admitting the existence, in these plants, of fecundating organs, but perceiving their difference from those of phanerogamous ones, have named them ÆTHEOGAMÆ. Lastly, there are some, as Gærtner and Borckhausen, who have designated them by the name of APHRODITES, in order to make it understood that they have, it is true, fecundated seeds, but that the fecundating fluid has no peculiar apparatus, and is secreted by the same organs, or in the same cavities, as those in which the ovules are found.

But all these terms, although admitted by distinguished naturalists, are less generally used than that of CRYPTOGAMOUS plants, which Linnæus very felicitously gave to this class of plants, and which is peculiarly applicable to them. This term indicates that the organs of fructification are not visible to the naked eye.

The name of Agamæ, which affirms the non-existence of fructifying organs, and the absence of all fecundation, probably expresses that which is not exactly true.

Perhaps it will one day be necessary to divide these plants into two classes:—1st. Cryptogamæ, properly so called, where fecundation is performed, although by organs scarcely if at all visible to the naked eye; and 2d, true Agamæ, which have no fecundation: but if, in

the present state of the science, we can affirm that the first of these classes does really exist, it would be as yet imprudent to declare that there are true Agamæ. We can easily understand, in fact, 1st, that the fecundating organ may have escaped, and still continue to escape detection by our microscopes, and it may afterwards be discovered; 2d, that if the same cavity contain the germ to be fecundated and the fecundating fluid, we might not be able to see the sexual apparatus, and, notwithstanding, fecundation may exist; 3d, that as in phanerogamous plants there are some which are reproduced with and without fecundation, it may happen in Cryptogamous ones, that these two modes of reproduction may also exist, but that reproduction without fecundation may be the most frequent.

The details into which we shall enter upon the different families of the Cryptogamæ, will tend to prove that these different reasons of doubt exist in several cases; I regard it impossible, in the present state of things, either to affirm that there are plants absolutely devoid of fecundation, or that all are endowed with it. I admit then the word Cryptogamous, in this sense, that it designates plants in which the fructification is obscure, or perhaps wanting.

The circumstance, which has most retarded the discovery of the sexual organs of the Cryptogamæ is, that for a long time, these plants were only studied at the period of maturity; for it is clear that then we should be no more able to find the male organs in them, than the stamens in phanerogamous plants when their seeds are ripe. It was the celebrated Hedwig who first made this remark, and who has succeeded in finding the male organs of several Cryptogamæ, by observing them at the period when they must be perceived, *i. e.* a long time before maturity.

A second difficulty which also contributes to cast doubt upon the structure of these plants is, that several of them appear furnished at the same time with both modes of reproduction ; thus, several Mosses and Hepaticæ present both reproductive bodies, which, proceeding from a fecundating apparatus, must be considered as seeds, and others which seem to be true bulbs. If the distinction between these two classes of bodies is so difficult in certain phanerogamous plants, we can comprehend how the difficulty must go on increasing here, seeing the smallness of the organs, and the almost impossibility of applying the laws of analogy.

In fact, that which is most remarkable among Cryptogamous plants is, that the families of this class compared together differ much more than the phanerogamous families, and that the most nearly related present diversities which would seem to declare a totally different nature; the laws of symmetry, which have so powerfully aided us in discovering the true nature of the organs of phanerogamous plants, can only be applied here in rare and uncertain cases; this obliges us to study each family in particular, without being able to derive from this examination any general laws for the entire class.

All Cryptogamæ are furnished with bodies which serve to reproduce the species in the same manner as seeds. The name of Spores has been given to them, a term which ought to be considered as provisional; for, when it shall have been proved that these bodies have been fecundated, we must call them seeds, and if it be demonstrated that they are not fecundated, they would take the name of bulbs.

In most Cryptogamous plants, perhaps in all, the spores are contained in a vesicle, or membranous capsule, to which the name of Sporangium is often given ; this organization is met with from the Ferns to the

Algæ, and it seems to be one of the constant characters of these plants; the Sporangia are sometimes so small, as to be taken for simple seeds, and the error is the more easy, as they seem to germinate when placed upon earth; at other times they have been confounded with the grains of pollen.

The most certain means of avoiding this last error, is to observe the series of phenomena as well as their form. The function of male organs is limited to the period of fecundation, and it is observed in all known plants, that the stamens perish after the emission of the pollen, and usually fall off in a short time; the female organs, on the contrary, which have been fecundated, then commence a new series of phenomena; they increase in size, become firm and opaque, and thus declare their true nature. This system, simple, and founded at once upon observation and reason, will enable us to recognise the nature of the different powders which are observed in the Cryptogamæ: the more fugacious will be considered as the male organs, the more lasting as female. We now proceed to examine, in a general manner, the structure of the different families.

Section II.

The Equisetaceæ.

We have seen, (Vol. I. p. 200,) on speaking of the structure of the Equisetaceæ, that their branches and the scales, the union of which formed their sheaths, are verticillate around the axis. This disposition is also met with in their organs of fructification. Their stems, and often their principal branches, terminate in an oval or

conical spike, composed of verticillate scales, each of which is a disc with five, six, or seven angles, borne at the centre upon a nearly cylindrical support. From the lower borders of the disc are prolonged downwards from five to seven whitish horns, which open by a longitudinal fissure on the inner side, that is to say, nearest the pedicel. There proceed from this slit, at the period of maturity, globules which, received upon paper and examined by the naked eye, present a kind of singular spontaneous motion.

When placed under the microscope, we perceive that each globule is formed:—1st, of a green central body, globular and compact; 2d, of two laminæ, dilated at their two extremities into small club-shaped bodies, placed crossways at the middle, at the base of a green body, and rolled spirally around it; these two laminæ, or four half-ones, are covered, especially at their swollen extremities, with small red or brown corpuscules. They are endowed with a very decided hygroscopic motion; they are rolled around the green body when moist, unrolled when they are dry, and evidently seem to serve for the purpose of dispersing the green bodies out of the horns which enclose them. What is the nature of these different organs?

Hedwig thinks that the green globule is an ovary, and that the elastic laminæ are stamens, the pollen of which is represented by the powder which adheres to their surface. That the green globule is a true pistil, is what Hedwig appears to affirm, asserting that in its young state it presents a small point, which afterwards disappears, and which he takes for the stigma. But is this ovary furnished with a cavity containing several seeds, as he appears to believe? Agardh and Vaucher invalidate this opinion by the following observation: they have seen that if these globules be plunged into water,

and if, after they have thus been made to swell up, they be placed upon moist earth, they elongate and ramify, and produce a young plant. This globule first gives birth to articulated and confervoid filaments, analogous to those which are observed on the development of the seeds of Mosses.

The green globule then is a reproductive organ, but it may be either a monospermous fruit, or a simple tubercule analogous to a bulb. This last opinion would seem confirmed by the fact, that in its development the foliaceous part does not appear to proceed out of an integument as in seeds, but that the seed itself appears to dilate.

As to the elastic laminæ, we cannot positively demonstrate their nature; on comparing them with stamens, which their general position seems to authorize, it must be confessed that several circumstances have been neglected:—1st, We have no example of elastic stamens which remain, without being obliterated, till the maturity of the fruit; 2d, We have no example of pollen in the form of globules placed on the external surface of the filaments; 3d, If the laminæ be filaments and their inflated parts anthers, it is at least singular that of four of these anthers two are placed on the side of the globule, not at the point where the stigma is supposed to be. In this state of circumstances I have great doubts upon the reality of the character assigned to these organs, and I am almost disposed to consider them as simple elaters analogous to those of the Hepaticæ, and intended only to promote the dispersion of the green globules; and if these latter bodies be true fruits and not tubercules, we might suppose that the fecundating matter is contained with them in the horn or follicle from which we see them issue.

Section III.

Of the Marsileaceæ or Rhizospermæ.

The Marsileaceæ are of all Cryptogamous plants those in which we most easily distinguish the sexual organs. Most of them have their parts of fructification enclosed in a kind of close involucrum, which appears divided into several cells. We may count four in *Pilularia*, and one in most species of *Marsilea;* in each of these cells or distinct cavities, we find unilocular sessile anthers, which contain yellow globular pollen, and pistils also sessile, formed of an oval ovary surmounted by a small stigma; these ovaries change into a monospermous indehiscent fruit. At germination, the seed gives birth, first to a radicle, and a leaf, the number of each of which afterwards increases, and they finish by forming a small bundle of roots and leaves. Bernard de Jussieu does not hesitate to consider them as Monocotyledons, near Ferns, on account of the circinate vernation of their leaves. *Salvinia*, also presents a closed involucrum, which encloses the male filiform organs surrounding a solitary ovary, surmounted by a sessile stigma, and inclosing several seeds. These three genera are specially organized to live in water and inundated places, since the organs of the two sexes are contained in the same closed envelope, so that the pollen may fall immediately upon the stigma. *Azolla*, which Mr. Brown refers to this family, differs from the other genera in the male and female flowers being contained in different involucra.

Section IV.

Of Ferns.

The Ferns have sometimes been called by the name of Dorsiferous or Epiphyllospermous plants, making allusion to one of their most striking characters, viz: that their fructification arises in general upon the back of their foliaceous organs, which may be considered either as true leaves, bearing, by a structure peculiar to this family, the organs of fructification, or as peduncles bordered with foliaceous limbs.

In favour of the first opinion, we may allege that these foliaceous organs are not always fructiferous, and that some Ferns bear their fructifications in spikes which seem distinct from the leaves, that they present absolutely the use and structure of true leaves, and are provided with stomata; that, lastly, there are some phanerogamous plants, as *Polycardia*, where we find a somewhat similar structure.

We may say, in favour of the second opinion, that the leaves without fructifying organs owe this state to an abortion analogous to that of peduncles transformed into tendrils or spines; that the pretended spikes of certain Ferns are only peduncles which are not bordered; that certain phanerogamous plants, as *Urtica membranacea* and *Paspalum membranaceum*, present peduncles bordered in a similar manner; that if petioles can be bordered with a foliaceous limb furnished with stomata, peduncles can also present the same singularity; and, lastly, that the example of phanerogamous plants with epiphyllous flowers are all doubtful when closely examined.

It is, perhaps, in order not to decide this question, that

several botanists have given to the leaves of Ferns the vague name of FRONDS.

Whatever term may be preferred for these pedunculate-leaves, or foliaceous-peduncles, we shall observe that their position upon the stem is similar to that of leaves, and that they may in like manner be divided into petioles and limbs furnished with nerves and parenchyma. Although the limb is often very much divided, there is never any articulation between its parts, and it must always be compared with simple leaves.

In general, those fronds which do not bear the fructification, as those of *Osmunda*, are large and foliaceous throughout their whole extent. This appearance is met with in all those which bear a moderate number of fructifying organs, for example, *Polypodium*, *Pteris*, &c. But when the number of these organs is very great, then the foliaceous limb diminishes and seems to disappear, being covered or hidden by the development of fruits; this is seen clearly in several species of *Acrostichum;* and following analogies which leave but little doubt, we come to understand that Ferns said to be spiked, as *Ophioglossum*, only owe this appearance to a more complete and constant abortion of the foliaceous limb. Let us also remark that in the cases where the organs of fructification are moderately dispersed upon the fronds, these latter still being able to perform the physiological functions of true leaves, may be all fertile, as *Polypodium*, *Pteris*, &c.; whilst, if the fructifying organs are accumulated in great numbers upon certain fronds, so as to deprive them of all the functions of leaves, it then happens that there are upon the same stem other fronds, said to be sterile, which perfectly enjoy the functions of leaves; this is seen in *Osmunda*, *Ophioglossum*, &c. The vernation of the fronds of all or nearly all Ferns is circinate, or in other terms, they are rolled up from the

apex to the base; this disposition, analogous to what is observed in the Droseraceæ and Cycadeæ, is remarked not only to affect the middle lobe of the leaf, but also each of its partial lobes. It results that at the moment of expansion the upper surface is entirely external, and the lower is protected by being thus rolled up.

When we examine Ferns under the microscope, at this period, we find, along the middle, oval, pedicellate, naked, scattered little bodies, which Hedwig considered to be stamens; and upon the part of the limb which is rolled up, we observe other bodies, more numerous, and concealed under a proper membrane. These last are, doubtless, the rudiments of young fruits, for we can follow their development on to their maturity.

As to the first, the opinion of Hedwig is founded upon the following reasons: 1st, they are only found at a period long before maturity, and disappear soon afterwards; this is the property of the male organs of plants: 2d, their form and appearance are analogous to those of ordinary male organs: 3d, if this character be not assigned to them, we shall be puzzled to attribute any other to them.

In answer to these arguments it may be objected:— 1st, that these bodies have as yet been seen in only a small number of Ferns; 2d, that their position is uncertain, and very different from that of the female organs; two circumstances which are contradictory with regard to the character assigned to them; 3d, that the female organs being covered over by a membrane, we do not see in what way fecundation can be performed; 4th, that observers have not as yet perceived the dehiscence of the organs which Hedwig considers to be males; 5th, that nothing appears to act the part of a style, or stigma, in those which he regards as females.

In opposition to the opinion of Hedwig, some natura-

lists have thought that the capsules of Ferns were kinds of bisexual flowers. Muratti was the first who maintained the hermaphroditism of the flowers of these plants. Hill and Œder have thought that the ring of the sporangium was the organ which contained the fecundating fluid. Gærtner and Mirbel have maintained that each of the globules contains, in its young state, the fecundating fluid and the ovules. This opinion is founded, not upon direct observation, which would be impossible, but upon the analogy of the Ferns with the Marsileaceæ, and upon the presumed necessity of fecundation.

Lastly, Bernhardi has expressed a new opinion upon the nature of the sexual organs of these plants: he thinks that the male organs are little bodies of a glandular appearance, sessile upon the small scales which are observed upon the upper surface of the leaves; that the ovaries of the female organs, situated in clusters on the lower surface, have kinds of styles which pierce the tissue of the leaf, and terminate in the pores on the upper side, performing the part of stigmata. In support of this opinion, he remarks that the points which he supposes to be globules of pollen, are situated at the extremity of vessels which appear stronger, and consequently more important than the neighbouring ones; that the scales are first of a yellowish brown colour, afterwards pale, and fall off, as anthers do; that the globules of pollen may pass along the upper surface of the leaf, as far as the points which appear to perform the function of stigmata. Bernhardi found species where the organs which he regards as males, are situated upon different leaves; such as, for example, *Onoclea Struthiopteris* and *O. crispa*, the sterile leaves of which are, according to him, the males; but in the greatest number of observed genera, as *Polypodium*, *Polystichum*, *Cyathea*,

Davallia, *Asplenium*, &c., the male organs are upon the same leaves as the capsules.

The theories of Hedwig and Bernhardi are at present the only ones which deserve attention, but I will not venture to say any thing upon the preference which ought to be given to either of them: that of Bernhardi presents, it is true, less objections; but the facts upon which he rests are known in so small a number of species, and have been observed so little in detail in those where they have been described, that it appears to me premature to adopt them without new examinations.

As soon as the leaf is developed, the male organs (I here speak collectively in the sense of the two hypotheses) disappear, and the female organs begin to increase. We see them gradually become elevated, and afterwards, at maturity, they break the pellicle which covers them; the clusters bear the name of SORI, and their integument that of INDUSIUM; the disposition of the clusters upon the limb or margins of the leaf, and the existence or form of the indusium, are the principal characters from which the classification of Ferns is derived: let us examine now the bodies of which the clusters are composed.

These bodies, at maturity, are of a brown or reddish colour, round or reniform, and furnished with a short pedicel. The name of CAPSULES, or more correctly that of SPORANGIA, is given to them; they are most frequently bordered with an elastic ring, which opens from within outwards, and causes the dehiscence of the cavity; in some anomalous Ferns the ring is absent, and the dehiscence takes place by a transverse rupture; almost all have the capsule unilocular; but in *Myriotheca* it is divided into several cells.

From this cavity there proceeds, at dehiscence, a small cloud of powder, which is composed of seeds or spores;

these are little corpuscules, usually round, and reddish-brown; when sprinkled upon a sponge or moist earth we see them evidently germinate, and reproduce the species which gave birth to them.

The seed or spore produces laterally a green body, at first nearly cylindrical, but which afterwards expands into a foliaceous limb, devoid of nerves, very similar to those of certain Hepaticæ, and which may be considered as the cotyledon; it sometimes becomes lobed at the apex, sometimes it surrounds the base of the plant, so that the following fronds appear to proceed from its centre. It frequently shoots out radicles, either from its margin or lower surface, and sooner or later is destroyed, as is the case with the cotyledons of phanerogamous plants. It only remains, for the complete assimilation of these organs with cotyledons, to be assured whether the foliaceous parts proceed from an integument, or whether they are a simple prolongation of the globule. The extreme minuteness of this body has not as yet permitted this to be accurately observed, but the analogy of this germination with that of Mosses, in which Hedwig asserts that he has seen the rupture of the integument, ought to make us believe that it will also be observed in Ferns.

There are ferns which are called viviparous, because young individuals are seen to arise from the margins of their leaves, or from the centre of their clusters of fructifications. This phenomenon may be compared, either to the development of embryos in *Bryophyllum*, or to the germination in the pericarp which is observed in certain species of *Cuscuta*. The Ferns in which this takes place are *Darea, Asplenium bulbiferum, A. ramosum, Cyathea bulbifera*, &c.

Section V.

Of the Lycopodiaceæ.

The family of the Lycopodiaceæ, although not numerous in species, is one of those, the structure of which is the most difficult to be understood. The diversity of organs which are found, either collected together, or separated in the different groups of the family, is the principal difficulty met with in this study.

The only species which may be regarded as sufficiently known, is *Lycopodium denticulatum*, very well described by Mr. Brotero, and figured by Mr. Salisbury in the Transactions of the Linnean Society; this species joined to *L. Helveticum*, forms a genus or particular section, to which the name *Diplostachyum*, proposed by Beauvois, may be retained, although the character is hardly correct. These species present two kinds of spikes upon the same plant, or a single spike, which encloses two sets of organs in the axil of the bracts. We find in the upper part of these spikes, slightly crustaceous, reniform, bivalve bodies, full of an angular, yellowish or orange powder. Mr. Brotero thinks that this organ is an anther full of pollen, and he affirms that he has sown it without his ever having seen it germinate. Beauvois adopts the same opinion. At the base of the spikes or on the shorter ones, borne upon the same plant, we find in the axils of the bracts other bodies, which are also crustaceous, and which open by four lobes, and contain four yellowish globules, marked at their base with three projecting ribs; these globules are seeds, for, in the midst of a great number which were abortive, Messrs. Brotero and Salisbury have seen some of them germinate; consequently the shell with four lobes which contains them

is an ovary; according to the former, the stigma of this ovary is represented by a pellucid and transverse line, placed at the apex; the same character is attributed to the little central protuberance which surmounts this line.

At the period of germination, we see the young plant come out of the seed by the side; its radicle is simple and perpendicular; its plumule rises vertically, and is terminated by two opposite leaves, from the axils of which spring two branches. Inside the seed is an oily body adherent to the embryo, which Mr. Brotero calls the VITELLUS, and which appears to me to be the true cotyledon; the two opposite leaves, which these observers call COTYLEDONS, represent, in my opinion, the primordial leaves. The change of character, assigned to these organs, appears to me sufficiently authorized, both because the vitellus is an almost imaginary organ, and because it is impossible to compare *Lycopodium* with *Dicotyledons*.

From well known facts with regard to *Lycopodium denticulatum*, we may easily conclude:—1st, that in *L. Selaginoides*, or the section *Selaginella*, the bivalve shells which Hedwig described as the female organ are the male, and the quadrivalve and reniform ones which he described as males are the female organ:—2d, that it is the same in the sections *Gymnogynum* and *Stachygynandrum* of Beauvois, although their structure has not been as well studied; but what is the character of the shells which are observed in the Lycopodiums composing the sections *Plananthes*, *Lycopodium*, and *Psilotum* of Beauvois; that is to say, in all the Lycopodiaceæ, where but one class of organs is known? Beauvois considers them always as males, and regards the females as unknown. Linneus also regarded the powder of these shells as analogous to pollen, on account of its inflam-

mable nature. This opinion would seem confirmed by the extreme analogy which is observed between the bivalve shells of the section *Plananthes*, compared with those of the section *Selaginella*, which analogy obliges us to consider as males; the contrary opinion has been maintained by Hedwig, but to support it he has been compelled to admit for the male organs of these plants kinds of foliaceous buds which do not resemble any known male flower. I admit then, with little doubt, that the bivalve shells of *Plananthes* and *Lycopodium* of Beauvois are male organs, of which we do not know the females; but I am much more uncertain with regard to the nature of the shells with three valves in *Psilotum*, although the globules contained in them appear to inclose fovilla rather than an embryo.

I have met with two organs analogous to those of *Lycopodium* in the genus *Isoetes*, which might be defined by the name of *Lycopodium aquaticum*. Having had an opportunity during my stay at Montpellier to see a living plant, I attentively examined it: the leaves spring from a kind of fleshy subterranean stem, slightly analogous to those of bulbous plants. Each of them bears in its axil a fructifying organ, or a flower which is adherent to it; in those which may be considered as the lower ones, we find a membranous indehiscent body concealed by a small foliaceous lamina, surmounted by a filament, divided internally into three compartments by small transverse columns, and enclosing about fifty spherical globules, marked at their base with three projecting ribs, as the seeds of *Lycopodium denticulatum*. In the axil of the central leaves we find other bodies very similar to the preceding, but which are divided internally into more numerous compartments, which contain an impalpable powder, at first white, afterwards black.

If I had caused either of the two powders which I

have described, to germinate, the history of *Isoetes* would have been completely elucidated; but having quitted Montpellier before I could do so, I am still in doubt with regard to the nature of these two organs. On the one hand, the extreme similitude of the three-ribbed globules with the bodies which Brotero has seen germinating, leads me to consider them as seeds; but I have always found them empty at the period of maturity, which would seem to indicate that they are of a male nature; moreover, the powder of the central capsules, which becomes brown and opaque at maturity, would seem more to represent seeds.

Gærtner and some other naturalists have considered the Lycopodiaceæ as devoid of sex, and furnished with two kinds of seeds; but this hardly probable opinion must be confirmed or destroyed by experiments upon the germination of the two kinds of powder.

Section VI.

Of Mosses.

Mosses are more distant from phanerogamous plants than the preceding families, since they are devoid of vessels and stomata; they present, however, various affinities with these plants in their organs of fructification, which are better known than in any other cryptogamic family. Hedwig has so extended the field of our knowledge with regard to Mosses, that, neglecting former opinions, I shall limit myself to the exposition of his, and only examine the later doubts and objections to the works of this philosopher.

The fructifying organs of Mosses are contained in kinds of buds, placed sometimes at the tops of shoots, sometimes laterally, and at other times even at the base of these shoots: those which are really terminal sometimes seem lateral on account of the elongation of the shoot after flowering. These buds, either star-like or capitate (for their appearance may cause these different names to be given to them), are formed of leaves imbricated without any order, and the number of which does not appear fixed. This envelope has received the name of Perichœtium when it is found at the base of the pedicellate fruits of Mosses, or, in other terms, around the female organs; and the name of Perigone, when it surrounds the male organs. These two terms, although generally admitted, appear to me to rest upon ideas hardly correct; in fact, it seems evident that these leaves constitute the same organ, and the frequent cases where they cover at the same time both the male and female organs, are sufficient to demonstrate it; moreover, when the organs of the two sexes are always separate, which is not the case here, one would not be more authorized to give two names to their integuments than to the calyx or involucrum of the two sexes of diœcious phanerogamous plants. If we ought to admit but a single name for identical organs, that of perichœtium ought to be rejected; that of perigone is less incorrect, but it also presents a great objection.

This term, already admitted for phanerogamous plants, supposes that the floral bud of Mosses is a simple flower, and this, in fact, is the opinion of Hedwig, and of almost all Muscologists. Others have thought on the contrary, that the floral bud of Mosses is a true capitulum formed of several flowers. I would willingly compare it with the compound flower of *Euphorbia*. The leaves which surround the fructifying organs

appear to me to be a true involucrum with several leaflets, inclosing sometimes the male, sometimes the female flowers, and more rarely the two sexes together.

The leaves of the involucrum, or the bracts of Mosses, differ from the ordinary leaves nearly as the bracts of phanerogamous plants, either in size, form, or even in colour; frequently the middle nerve is absent when the other leaves are furnished with it. At other times they are prolonged into a long bristle, which is wanting in the ordinary leaves; sometimes those of the two sexes or those of different rows differ from one another; but these leaflets are never verticillate as in the perigone or calyx, but always imbricated as in involucra.

In these capitula, whatever be the sex of the organs they contain, are found an indefinite number of simple divided filaments. Hedwig has given them the name of PARAPHYSES; they are most frequently cylindrical, and longer than the sexual organs; we find some which are gradually thickened towards the apex, and others abruptly dilated into an oval or globular kind of club. They usually spring from very near the base of the sexual organs. They have been compared to the nectaries of flowers, but I have already shown in what a vague sense this word was used; I should be inclined to compare them with the little scales found in the involucra of *Euphorbia,* and to regard them either as bracteoles, or as the rudiments of a true perigone. They continue for a long time without changing their form, and their function, with regard to the fructification, is entirely unknown.

The male organs of Mosses are found scattered among the paraphyses in an indefinite number: they entirely compose the male capitula of the monœcious or diœcious species, and surround the female organs in the hermaphrodite capitula. Each of them is composed of a very

short and sometimes scarcely visible filament, and of an oval or oblong sac or anther: this sac presents no trace of a suture, and is unilocular; the apex presents a glandular point, by which, at maturity, the cell opens, and we see it emit, in intermittent jets, a viscid fluid. Does this represent the fovilla contained in the grains of pollen? or, do the pollinic globules here swim in a particular liquid? This liquid, as well as all the male organs, is of a greenish colour; after it has been emptied, the half-dried sac takes a yellowish or brownish colour, and the cellular organization is visible to the microscope under the form of a net-work. In a small number of Mosses, *Sphagnum palustre,* for example, the anther is large, oval, and borne upon a long filament.

The female organs of Mosses, considered at the time of flowering, entirely compose certain capitula said to be female flowers, and are found in the centre of those called hermaphrodite ones. In both cases their number varies from three to four, or even eight or ten; but, whatever be the number, there is hardly ever more than one which arrives at the state of fruit; the others become abortive, and are thrown off under the form of scales intermixed with the paraphyses.

Each organ is sessile or nearly so; at the time of flowering, we distinguish an ovary, usually oval and of a reddish brown colour, a filiform style of the same colour, and a slightly expanded stigma opening at fecundation. All this apparatus is surrounded by a membranous integument, which, after flowering, is elevated by the elongation of the pedicel of the fruit, breaks at the base, and receives the name of CALYPTRA, on account of its hood-like appearance. Hedwig considers it as the corolla of Mosses, and this comparison is tenable, provided that we only consider it as a short way of indicating that it is an intimate integument of the flower:

but in the opinion which this author had that the capitulum of Mosses is a simple flower, this term was contradictory with regard to his own theory; for each female organ has its own calyptra; and in that which he called hermaphrodite flowers, he said that the corolla was situated within the stamens. These difficulties do not exist when the capitula of Mosses are considered as aggregated flowers. The calyptra is the integument of each of the female flowers, and may be compared to the perigone of monochlamydeous flowers.

After flowering, the calyptra, elevated by the elongation of the pedicel, is broken across near the base; sometimes, as in *Sphagnum palustre*, the lower part remains at the base of the fruit, but most frequently this is not visible, and the calyptra remains placed as a small cup at the top of the fruit, and falls off at the approach of maturity. Sometimes the enlargement of the fruit causes it to break laterally, at other times the pedicel curves at the apex, so that the fruit is pendent, and the calyptra drops off, which organ, at this period, is always membranous or half-withered, resulting from its having no longer any organic connexion with the plant; it is almost always smooth, but it sometimes bears hairs, which appear to be the remains of paraphyses united with it; these hairs are directed upwards in *Oligotrichum* and *Orthotrichum*, and downwards in *Polytrichum*.

The pedicel, which was so short at the period of flowering as to be hardly visible, afterwards elongates so as often to be longer than the stem; it is a true thecaphore, and is slender, simple, cylindrical, firm, and composed of compact elongated cellular tissue. The name of Pedicel or Bristle, *(seta,)* is given to it.

The Theca, which terminates the pedicel, is the true pericarp; its form is most frequently oval, sometimes either tapering or swollen at the base, or slightly pro-

truding laterally. It opens at maturity by a true circular dehiscence, which takes place near its apex; the upper part, which resembles the cover of a vessel, has received the name of OPERCULUM; it is slightly depressed at the margins, and conically elevated at the centre.

After the fall of the operculum, we see that the inner border of the theca is furnished with one or two membranes terminating in regular teeth; these membranes bear the name of PERISTOME *(peristoma)*, because they surround the opening of the theca. The peristome, when there is but one, or the outer one when there are two, is very remarkable for its diversities of form and its irregularity; in a small number of cases it bears no teeth, as in *Gymnostomon;* most frequently it is bordered with teeth or cilia, which are always equal and of the number four, or one of its multiples, four in *Tetraphis*, eight in *Splachnum*, sixteen in *Grimmia*, thirty-two, forty-eight, or sixty-four, in different species of *Polytrichum*. In several cases each tooth is half-divided by a fissure, as in *Dicranum*, and in the same case where it is not found, we perceive traces of it under the form of longitudinal lines. We might believe that the number of teeth is as great in the normal state, and that they are united two and two, three and three, four and four, &c. The inner peristome only exists in a part of the Mosses; it is more membranous; its margin is divided into 8, 16, or 32 teeth, which are often more unequal and irregular than those of the outer peristome.

In some genera, as *Polytrichum*, the tops of the teeth of the peristome are all united together by a transverse membrane stretched over the entrance of the theca; this membrane bears the name of EPIPHRAGM; when it exists, the seeds can only come out between the teeth. In almost all the other genera the teeth are free, and are endowed with a very decided hygroscopical motion; they

are curved inwards when they are moist, and outwards when dry; by means of this motion they raise up the operculum, and facilitate the dispersion of the seeds.

The centre of the theca is occupied by a vertical axis called the COLUMELLA, which proceeds from the base and reaches the top of the operculum, to which probably it bears nourishment; it is sometimes cylindrical, at other times slightly swollen in the middle; its apex is obliterated at the fall of the operculum.

The seeds or spores are very numerous, attached, according to Hedwig, to the walls of the theca and to the columella; they are very small, reddish or brown at maturity, and of a globular or round form. Hedwig has seen those of several species germinate; from his account, the integument breaks, and the young plant presents at its birth a descending filament, which might be taken for a radicle, and a cylindrical divided body, which appears to be a kind of cotyledon; there are afterwards developed kinds of cylindrical and branching primordial leaves, the number of which is uncertain; they remain for a long time in certain species, as *Phascum Confervoides*. Mr. Drummond, who has observed the germination of Mosses since Hedwig, asserts that these confervoid filaments penetrate the earth and form roots.

This theory of the reproduction of Mosses, although hitherto universally admitted, has not been free from contradiction: some have begun to deny facts upon which there is at present the most accordance; others, admitting the structure of the organs, have denied the use assigned to them, more, it appears to me, from general opinions upon the absence of sexes in Cryptogamæ, than from the real examination of facts. The principal positive objection has been, that it is difficult to conceive how the female flower, invested with its calyptra, can be reached by the matter emitted by the

anthers, and especially in the diœcious capitula; but nothing prevents our admitting (and several say that they have seen it) that at this period the calyptra is slightly open at the apex, or we might believe at least that there is some direct communication with the stigma. It has also been said, that the mode of fecundation described above is impossible in aquatic Mosses; but Hedwig has remarked that when they flower, which is very seldom, the tops are then raised above the water.

Beauvois has maintained, that the whole reproduction of Mosses is performed in the theca alone, partly founding his opinion upon the very small number in which male organs have as yet been perceived. He thinks that the seeds of Hedwig were the pollen, and that the true seeds were inclosed in the columella. As an objection to this theory, has been urged the improbability of finding the pollen at the same time as the ripe seeds, so perfectly resembling them in size and form, and in so great a quantity; it has been especially answered by the germination of the pretended grains of pollen. Finally, Mr. Robert Brown appears to have found the cause of the illusion of Beauvois; when the theca is cut transversely, the knife carries with it into the columella some of the seeds, which are those which he believes are lodged there; but when the columella is either cut lengthways, or after having completely isolated it, we find nothing but cellular tissue devoid of seeds.

Besides the sexual reproduction which we have described, Mosses are also propagated by shoots which proceed from the trunk, and taking root, form new individuals. This mode is common in aquatic Mosses, and those of very damp places, which rarely flower.

Section VII.

Of the Hepaticæ.

The family of Hepaticæ, though very natural, presents forms too dissimilar for it to be convenient to describe it in a collective manner; it will be more clear to speak successively of the small number of genera which compose it, beginning with those which have most affinity with Mosses.

The Jungermanniæ, which form the most numerous genus of this family, have been unfortunately described by Linneus, who designated their fruit by the name of anther, and confounded under the name of female flowers the true male flowers, and the gemmules. Schmidel was the first to clear up this difficult subject; Hedwig has confirmed and extended his observations, and Dr. Hooker has thrown a new light upon it in his excellent Monograph.

The Jungermanniæ are all monœcious; the male flowers are presented under the form of whitish anthers, solitary, sessile or nearly so, oval or ovate, composed of a fine reticulated membrane, full of pollen, and situated along the nerves of the leaves, or more rarely scattered upon the disc. Dr. Hooker has made them known in more than forty species of this genus. These anthers are usually naked, sometimes surrounded by leaves analogous to an involucrum or perigone. The female flowers are produced in very different situations; they are almost always surrounded by a foliaceous or membranous calyx, or perigone, sessile upon the stem or the leaf, and most frequently of a single piece, tubular, or slightly dentated at the apex; it is only absent in a very small number, as *Jungermannia concinnata*, and

J. Hookeri; it is found double in *J. Lyellii* and *J. Hibernica.* Each calyx incloses from three to four, or ten linear pistils, very like those of Mosses, and covered in the same manner with a calyptra, which differs from that of Mosses in its being broken at the apex; consequently it is not raised with the fruit, and it forms a kind of membranous cup at the base of the peduncle, which, as in Mosses, is but little if at all visible at flowering, and elongates much and very rapidly at the approach of maturity; this peduncle is almost always of a whitish colour, delicate texture, and formed of very elongated cellules; the theca or capsule is globular, brown, always devoid of an operculum, and opens at maturity by four spreading valves; it contains a great number of seeds attached to filaments or linear lamellæ, elastic, very hygroscopic, rolled up as a snail-shell, and most frequently of a brown colour: they are called ELATERS; they appear intended for the dispersion of the seeds, which are spherical, brown, and opaque. Hedwig has seen those of *Jungermannia epiphylla* shoot out, at germination, a simple radicle, and dilate at their upper part into a leaf.

Besides these seeds, they have likewise almost every kind of gemmæ or bulbs which serve to reproduce them: it also appears that the bodies collected into a compact head, at the top of the leaves of some species, as *Jungermannia nemorosa,* and which Hedwig considered to be male flowers, are nothing but collections of bulbs.

Marchantia does not differ from *Jungermannia* as regards its fructification, except in the following circumstances:—1st. The anthers, though resembling in form those of *Jungermannia,* are collected together, and, as it were, regularly inserted into an orbicular disc, nearly flat, slightly wavy, and borne upon a long peduncle. 2d. The female flowers, organized as those of the Jun-

germanniæ, are sessile at the lower face of a star-like pedunculate disc, and directed downwards; the capsules only open at the apex, by scarcely distinguishable teeth, and the elaters are more slender. 3d. The bulbs are more frequent, collected in kinds of sessile cups.

In *Anthoceros* the male organs are, according to Hedwig, oval anthers, slightly pedicellate, collected three or four together, in points scattered upon the disc of the leaf, at first concealed under a pellicle which breaks, and forms around them a kind of perigone. The female flowers also grow upon the disc of the leaf; they are at first presented under the form of a cone, they pierce it through at the apex, and retain the remains at their base, under the form of a sheath; they afterwards have an elongated bivalve capsule, which opens longitudinally, and then presents an isolated filament situated in the axis of the fruit. The seeds are spherical, slightly bristly, and furnished with compressed laminæ, which appear to perform the part of elaters.

Targionia only presents a globular capsule surrounded by a perigone; the seeds are devoid of elaters. Sprengel thinks that the male organs are corpuscules scattered upon the membrane situated around the female flower, and which perish before the maturity of the fruit.

Finally, *Riccia* only presents for the fruit, according to Hedwig, kinds of univalve capsules, buried or sunk in the leaf, surmounted by a small filament which seems to be a style, and containing several ovules devoid of elaters. The male organs are small whitish points, sessile, and scattered upon the leaf near the margins of its expansions. But the mode of reproduction of these two last genera deserves to be studied.

Here ends the series of cryptogamic plants, where we can recognise the sexes with any degree of precision. In the following families we shall find no organs which

can, with any likelihood, be considered as males, and if fecundation take place, it is probable that the fecundating fluid is contained in the same cavities as the ovules, without having any apparatus of its own.

Section VIII.

Of Lichens.

Lichens, considered with regard to their fructification, present kinds of discs or tubercules, which have received the common name of Apothecia, and to which that of Shields *(scutellæ)*, or Lyres *(lyrellæ)*, are given when it is wished to designate their particular forms. All these apothecia contain, at maturity, what appears to be the true fruit, in which we find oval or globular, opaque, blackish bodies, which appear to be the reproductive corpuscules; they have never, however, been seen to germinate, but it is only by analogy, and not by direct observation, that they are compared to seeds or spores.

This point being almost universally admitted, one is asked if these bodies have been fecundated, and if the function of a male organ can be attributed to any known part of Lichens. Some have thought that certain farinaceous efflorescences which are observed on different parts, were masses of pollen; others have believed that the nearly globular parcels of pulverulent matter, collected at the extremity of certain lobes of the thallus, replaced this function. Others have attributed it to kinds of cavities hollowed out in the thallus, and where it is said that a poliniform matter is found. Neither of these opinions is founded upon proof, or even upon sufficient

probability; and we may object to all of them, because the greatest number of Lichens are devoid of the organs to which so important a function was attributed, and consequently it is more probable that these efflorescences, or warts, peculiar to certain species, are connected with more general uses. Cassini has shown that the globules collected at the extremities of the leaf of *Physcia tenella* are capable of reproducing a new individual, and it is likely that we ought to consider them as bulbs, and that the globules analogous to these in other species are of the same nature.

Those who, knowing the truth of these observations, persist to admit fecundation in Lichens, have been compelled to suppose, either that the pollen was produced by the margin of the shields, which is usually rolled inwards at the period of the first development of these organs, which must be supposed to be that of the flowering, or that the fecundating matter is contained in the cavities with the ovules. It is evident that nothing can show either the truth or falsity of these opinions, founded, not upon observation, but upon the theory of analogy; if they be true, the supposed reproductive corpuscules of Lichens are real seeds.

Others, not willing to admit this, which it is possible to see, and denying, perhaps imprudently, the existence of that which does not fall under our senses, have unhesitatingly decided that Lichens are devoid of male organs, and of fecundation; consequently some have called them Agamæ, others Anandræ, some Inembryones, and others Acotyledons; but all have been evidently guided by an hypothesis—the non-existence of fecundation. If this opinion be true, the reproductive corpuscules are bulbs.

As I do not know any reason for admitting or rejecting either of the two theories which I have mentioned,

it is convenient to give these corpuscules a name which, if I may thus speak, will be entirely neutral; those of SPORES or GONGYLES have been proposed, as not affirming any thing beyond what appears known.

SECTION IX.

Of Fungi.

The immense family of Fungi presents forms so varied, that I should greatly exceed the limits of this work if I were to attempt to describe them. I shall confine myself to stating that all Fungi, taking this term in the more extended sense that botanists have assigned to it, present, at their maturity, globular coloured bodies, which are regarded as reproductive corpuscules, or in other terms, spores or gongyles; they are placed very differently in the various tribes :—sometimes inclosed in the body itself of the Fungus, as in the Truffle, &c.; sometimes situated on the surface, as in *Clavaria;* at other times between the lamellæ, as in *Agaricus, Boletus,* &c. &c. These are considered the reproductive bodies, although they have never been seen to germinate. We observe them in two states:—sometimes, as in *Agaricus,* they appear in the form of an impalpable powder, which separates at maturity from the membrane which produces it, and which is called the HYMENIUM; in this case they appear to be naked spores: sometimes, as in *Sphæria,* we see them contained in a membranous envelope, which is a SPORANGIUM, most frequently in the form of a globe or oblong spindle. In both cases, the spores or sporangia may be dry in cavities or upon surfaces which are not mucous; sometimes, as it were,

immersed in cavities or upon surfaces which secrete a particular mucus; the sporangia, when they are not imbedded in mucus, frequently adhere to divided filaments.

As to the fecundating organs, there is still the greatest doubt upon their existence. Bulliard has remarked that in some species of *Sphæria* there exists, independently of the sporangia of which we have spoken, a white fugaceous inflorescence, which he supposes analogous to pollen. Hedwig has believed that he has perceived, both in the cells of *Sphæria* and upon the margin of the cap of *Agaricus*, kinds of bodies filled with pulverulent matter, and which he thinks are the male organs. But neither of these assertions is founded upon observations sufficiently positive, or extended to a sufficient number of species, for it to be possible to repose any confidence in them.

It may be said that the fecundating fluid is inclosed with the spores in the sporangia, or around them in the cavities which contain them. This may be so; but those who affirm it do not know more about it than those who deny it. It would be premature, then, to give the least importance to theories which are not founded upon any positive facts. Until these are well known, if ever they can be, we shall call spores or gongyles the fecundated or unfecundated corpuscules, which we suppose, from analogy, to reproduce these plants.

The practical multiplication of the mushroom (*Agaricus campestris*), which is performed by means of the remains of old layers, or of what gardeners call mushroom spawn, does not serve to elucidate the theory of the reproduction of these plants; in fact, in this rude operation, they heap up without any order both the remains of the roots as well as the caps of old mushrooms, and we may as well believe that reproduction

takes place by shoots or suckers, as by germination of seed; even admitting this last hypothesis, the fact has not yet been observed in detail.

Section X.

Of Algæ.

In the same manner as in the preceding article I have spoken, under the collective name of Fungi, of all the Cryptogamæ of a fungous nature; here also I shall combine under the name of Algæ all cellular aquatic plants. I do not pretend to give this definition as a strict classification, but the sense in which it is here taken, though very vague, is sufficient for my present purpose. Considering these plants collectively, with regard to fecundation, we see, that if they are provided with a fructifying apparatus, they must have it organized in a particular manner; their pollen, or at least the fovilla, must be able to reach the ovules through the water; this, perhaps, happens in the Characeæ: or the fecundating matter is inclosed in the same cavities as the ovules, or transmitted to these cavities by particular canals, which perhaps is the case in the Thalassiophytæ and Confervæ; and even admitting that several groups of Algæ are furnished with fructifying organs variously formed, there are others in which the most scrupulous investigation has not been able to discover any vestige of sexual organs, and which only appear to be reproduced by simple division: such are the Batrachospermeæ and Diatomeæ.

We shall notice these different groups without

pretending to give here a methodical arrangement of the Algæ.

Those who desire to study the subject more in detail should consult the works of Muller, Hedwig, and especially those of Bory St. Vincent, Agardh, Lymgbye, and Fries.

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§ 1.—Of the Characeæ.

The Characeæ, though composed of the single genus *Chara*, present an organization so remarkable that we cannot as yet affirm what is their true place in the natural system. I have elsewhere (Book II. Ch. IV. Sect. 6) spoken of the structure of their stem; it only remains for me to make known that of their flowers and fruit.

Upon the inner side of the verticillate branches of *Chara* there arise from each node two little bodies which appear to be the sexual organs; one of them, situated a little below the other, and laterally, seems to be the male apparatus, for it disappears very soon; the other, surrounded at its base with three or four little branches, appears to be the female organ, for it remains long after the other, and produces a new individual.

The male apparatus or anther is a red reticulated disc, bordered by a white transparent membrane formed of cellules, the partitions of which are distinct. When this body is cut across, we see it filled: 1st, with divided transparent filaments; 2d, with oval corpuscules filled with the red matter which colours the disc; this matter comes out when the membrane which contains it is pressed. Hedwig and Vaucher consider these bodies as grains of pollen, and the matter which they inclose as the fovilla.

The objections made to this opinion are—1st, that no one has seen the anther open to give passage to the

globules; but Hedwig answers, that this may take place, or at least that the fovilla may come out, by imperceptible pores; 2d, that the flowering taking place in water, it is not known how the fovilla reaches the female organ: but Vaucher explains this anomaly by the nature of this fovilla, which is resinous and does not mix with water.

Others have thought:—some, that this apparatus or red disc was a kind of swimming bladder; others, that it was an apparatus containing a peculiar kind of seeds; but its fugacity, its appearance at the moment when the other is developed, have caused almost all naturalists to regard it as a true anther, in which it remains to be discovered in what manner the fovilla can escape.

The female apparatus is composed—1st, of three or four very short branches which surround it at the base, forming for it a kind of involucrum; 2d, of an oval body, marked with five or six lines disposed in regular spires, enclosing a green opaque body surmounted with five or six lobes, each of which is situated at the top of one of the lines. Vaucher considers these as stigmata. Hedwig considers them as prolongations of an adherent calyx, and says that he has remarked near their centre a projecting point, which he considers as the true stigma. This last opinion appears more likely, because it accords on the one hand with the position of the lines, and on the other with the solitariness of the central body.

This body is filled with a multitude of little globules of different sizes, which Hedwig and Martius consider as spores or seeds, but which Vaucher denies to be so, without affirming anything upon their real nature.

This observer has shown me, that when the whole apparatus above described is placed in water, it opens at the top into five teeth, and there comes out of it a cylindrical filament, which is the stem of a new individual,

and from the base of which is prolonged a radicle surrounded with little radical fibrils; it is not then doubtful that the central body of this apparatus is a reproductive body. But is it a monospermous fruit, as Vaucher seems to believe? Is it a fruit containing several seeds, one only of which is developed at germination?

This remains to be investigated.

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§ 2.—Thalassiophytæ.

I designate with Lamouroux under this name all the marine Algæ described under the names of *Fucus*, *Ceramium*, and *Ulva*. In order to make their reproductive system known, I shall select some examples from the different groups.

Fucus vesiculosus presents at the extremity of its ramifications kinds of oval swellings; these are not projecting tubercles, but simple dilatations of the tissue: the surface of this dilated part presents kinds of round pores disposed regularly. When, at the period of fructification, this dilated part of the frond is cut, we see that it is formed internally of a cellular tissue, very much swollen up with an abundant watery mucus differing in consistence from the juice of the rest of the plant. Under each of the pores on the surface is found a round mass, which seems formed of divided filaments, transparent, and interlacing one another: these masses, seen by the naked eye, do not bear a bad miniature resemblance to the prickly husk of the Chestnut. If they be cut across, we find in their interior a grand number of oval membranous bodies, which, at maturity, appear isolated from the rest of the tissue, and destined to come out of the

husk by the pores of the surface. The oval bodies, placed under the microscope, appear dotted, and this results from their containing a great number of small globules; on observing a recent specimen under the microscope, I have several times seen these sporangia open by one of their extremities, and there comes out a viscid mucus, heavier than water, which falls to the bottom of the glass on which it is placed, carrying with it the seeds swimming with it, and which, on account of their opacity, were visible in the sporangium before its dehiscence. It is evident that these granules are the spores or seeds, and that the young plants proceed from them.

But have these reproductive grains been fecundated? This point is very obscure. Réaumur has taken for the stamens of *Fucus*, certain divided diaphanous filaments, which grow in little tufts upon *Fucus serratus*, *F. vesiculosus*, &c.; but these appear to me to be simple productions analogous to hairs: in fact—1st, their texture indicates nothing which calls to mind the structure of an anther, and there cannot be perceived either pollen or fovilla;—2d, they are only found upon a small number of species;—and, 3d, in those even which are furnished with them, they are scattered over nearly the whole surface, and remain all the year—two circumstances which are incompatible with the idea of considering them as stamens. Correa has given a much more likely opinion, in admitting that the fecundation of these plants is performed by the viscid mucus which surrounds the bristly masses; but this opinion is, perhaps, impossible to be demonstrated in a direct manner.

Whatever it be, every *Fucus*, which has the frond dilated at the period of fructification, comes, with slight differences, under the description which I have given.

There is another order of *Fucus*, in which lateral

tubercles are produced at the period of fructification; these are pierced at their apex by a round pore; and I have seen in *F. Confervoides,* in a fresh state, the sporangia come out through it in intermittent jets; these sporangia do not differ from those of *F. vesiculosus;* but we find in the tubercle, where they are lodged, nothing like the bristly masses or even the viscid mucus of which I have spoken above. This is my principal objection to the theory of Correa; and if one wished to admit the existence of a fecundating fluid, it must be said that it is that which is found with the spores in the sporangia; for it is this alone which is observed in all the Thalassiophytæ. *F. pinnatifidus* only differs from those which I have mentioned in the sporangia being pear-shaped instead of oval. The fructification of *Ceramium* presents little difference from that of the Fuci with lateral tubercles; but I have not sufficiently studied it to describe it. As for the marine Ulvæ, they only appear to differ from the Fuci in their sporangia, which are oval, and perfectly like those of *F. vesiculosus* and *F. Confervoides,* growing in parcels in the tissue of the frond, and, as this is not pierced, they can only come out by the destruction of the tissue; it is this which causes the regular holes, often found in old species of *Ulva.*

It results from these descriptions, that all the Thalassiophytæ have spores contained in a membranous sporangium, floating in a viscid fluid which, at maturity, sinks to the bottom of the water, and serves probably to attach them to rocks. At germination, these spores are developed by forming a small cup, more or less regular, which disappears in most, but is met with in *Fucus Loreus,* for example, at an advanced age. The sporangia are collected several together, or lodged in the tissue of the leaf, as in *Ulva* and certain Fuci, or in lateral tubercles, as in the other Fuci and *Ceramium;* they come

out either by the destruction of the tissue *(Ulva)*, or by regular pre-existing pores *(Fucus)*.

In all these plants it frequently happens that the spores germinate in the sporangia, or in the cavities which contain these bodies; this we can easily see by the naked eye.

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§ 3.—Confervæ.

The Confervæ (I use this term here in the sense in which Vaucher has employed it) all grow in fresh water. Notwithstanding their external resemblances, they present great differences in their reproduction, which I shall rapidly point out, taking for my guide the excellent work of Vaucher *(Histoire des Conferves d'eau douce)*.

The Vaucheriæ, or Ectospermæ of Vaucher, present, at the period of fructification, sessile pedicellate tubercles, solitary or in pairs, or sometimes collected several together upon a peduncle. These bodies separate naturally from the plant, and Vaucher has seen them germinate: at this period they usually shoot out a green filament like the plant which has given birth to them; more seldom another filament proceeds from the opposite side. The body is not seen to open for the development of these filaments, so that we may as well consider them to be bulbs as seeds. Vaucher has also observed in most species of this genus little clubs or hooks, from which he has seen a fine greenish powder proceed: he considers them as male organs.

The Zygnemæ present a much more complicated organization. At the period of their fructification, their filaments approach one another by pairs; from one filament to the other there are kinds of hollow tubercles,

forming transverse passages. A fine green-coloured matter, disposed in a radiated or spiral manner, or in a mass, passes from the cellules of one of the filaments into those of the other; we then see either this matter collect in each cell into a globule, or, what is more probable, a globule, hitherto imperceptible, enlarges after this (perhaps prolific) operation, and is transformed into an oval body, which comes out of the cell by the rupture of its partitions. This body opens at germination into two valves, and there proceeds from it a filament very like the plant that gave birth to it. It is difficult not to believe that these reproductive bodies are true seeds, and that the green matter performs the part of pollen. This coupling of the filaments is also so remarkable, that, although no one has yet been able to discover any movement in these beings, one would readily be induced to place them in the animal kingdom.

The Chantransiæ, or Polyspermæ of Vaucher, present a third mode of fructification. Their internodes slightly swell up at the period of fructification; and by the destruction of the tissue, a multitude of oval globules comes out of each. Vaucher has seen them shoot out, either by one of their extremities, or more rarely by both, a divided filament resembling the mother plant. This kind of germination sometimes takes place without the globules coming out of the cell; and it is this that makes me think that the Proliferæ of Vaucher do not essentially differ from his Polyspermæ.

These three modes of reproduction are the only ones in which we can perceive an apparatus analogous to a true fructification. In the other genera we only see, it appears to me, a simple division, but which is presented under very different forms.

Thus, in *Hydrodyction*, each partial filament, which forms one of the sides of the pentagonal areolæ of which

the whole sac is composed, separates, swells up, and forms a sac resembling that of which it formed a part, without our being able to distinguish any thing that can be compared to a seed.

In the Batrachospermæ little buds detach themselves, which are developed and produce a new individual in a manner more analogous to reproduction by bulbs than any other.

In the Diatomeæ the filament is continually broken across by rectilinear dehiscences, and each fragment, which at first seems simple, appears double, &c., and is itself subdivided by transverse ruptures.

The Oscillatoriæ do not differ perhaps from this mode of division, and as they present a kind of motion, apparently independent of external causes, they are placed by most naturalists in the animal kingdom. We here touch the limits of two organized kingdoms, and find here no other mode of reproduction than that of simple division.

BOOK IV.

OF THE ACCESSORY ORGANS; OR, OF THE MODIFICATIONS OF THE FUNDAMENTAL ORGANS, WHICH RENDER THEM CAPABLE OF SERVING AS THE MEANS OF PROTECTION FOR THE OTHER ORGANS, OR OF FULFILLING OTHER ACCESSORY USES.

In Book I. we have described the elementary organs common to all plants; in Book II. we treated of the fundamental organs of plants, that is to say, of those which constitute their framework, serve for their nutrition, &c.; and in Book III. we have followed the numerous modifications of the fundamental organs as regards their transformation into reproductive ones. It now remains for us to point out other modifications of the fundamental organs both of those destined for the nutrition, properly so called, and of those which seem intended for reproduction : from these modifications results their transformation into organs very different from those from which they are derived; they become suited for new uses, which are almost all related either to the support, defence, or protection of the organs essentially destined to nourish or multiply the individual. It is to indicate this less degree of importance, and this, as it were, subordinate function, that I have given them collectively the name of Accessory Organs. I have already made some slight mention of them when speaking of the organs from which they are derived; I shall now describe their origin, form, and use. It is in these different points of view that I shall speak of Thorns, Tendrils, and of the different foliaceous, fleshy, petaloid, and scaly expansions of plants.

CHAPTER I.

OF THORNS.

I HERE designate under the general name of THORNS (*Arma*) all the organs, or parts of organs, which degenerate into a hard and more or less sharp point, and which become kinds of defensive arms for the plants furnished with them. It has been usual to distinguish them into spines and prickles; but this distinction is less easy than was at first thought. It has for a long time been said, that spines proceed from the wood and prickles from the bark; but from this definition it must be admitted, that only one of the organs exists in Monocotyledons, where the wood and bark cannot be distinguished, and one would even be puzzled to say whether they belonged to spines or prickles; in Dicotyledons themselves, there has been uncertainty in knowing to which class ought to be referred the thorns of several leaves, and those which grow upon the flower and fruit.

In this state of the science, I have remarked that all the organs of plants are capable of taking, at their extremities, a degree of induration which transforms them into thorns; and it has been easy to see that those, which, until then, had received the name of PRICKLES (*Aculei*), rather from some vague analogy than from any strict definition, were organs of the nature of hairs, indurated and larger than ordinary, and that all the organs transformed into prickles came to be, and have been, generally considered as SPINES (*Spinæ*).

Some examples will place these principles beyond doubt, and will serve at the same time to make known the varieties and origin of spines and prickles.

The circumstance which most frequently produces spines is the defective development of the branches of certain trees which become indurated, and thus are transformed into thorny points: thus, for example, the spines of *Prunus spinosa*, the common Sloe, are evidently only indurated branches; they spring from the axils of the leaves like branches, and frequently bear leaves; their structure is absolutely that of branches; moreover, when one of these plants is found in a very dry soil, there are more spines, or, in other terms, many more abortive branches; if, on the contrary, it grow in fertile land, it loses its spines—that is to say, all its shoots, instead of being abortive, are prolonged into true branches. It is on account of this circumstance, common to several trees and shrubs, and especially those of the Rosaceæ, Amygdalaceæ, &c., that we often observe that spiny plants lose their thorns by culture, as I have observed in the wild Medlar, in which all the spines disappeared in two years. The spines of *Gleditsia*, which are so enormous and branching, those of *Genista*, *Cytisus*, and a multitude of others, are only abortive and indurated branches. We might say that these are ramal spines.

The petioles of some species of *Astragalus*, of *Halimodendron* and *Ammodendron*, present an analogous phenomenon; they harden at the end of the life of the leaflets, and when these fall off, or are ready to do so, they change into very hard and sharp true petiolary spines: from the nature of their origin, they are always simple; they become almost as hard as the stem itself; for all petioles which have this spinescent tendency are continuous, and not articulated at the base.

The stipules of several plants become so indurated as to present the appearance of true stipulary spines: such are those of *Pictetia.* But it must be observed, that the *coussinets,* or protuberances of the branch upon which the petioles are placed, sometimes acquire so large a lateral development as to form true spines, which have often been taken for stipulary ones: they are very well seen in certain species of *Acacia,* where they coexist with the true stipules, in *A. Hæmatomma* for example; but when only one of these two organs is met with, it is almost impossible to affirm whether the spines on both sides of the leaf are indurated stipules or lateral expansions of the *coussinet.* Analogy with neighbouring plants can alone remove the doubt.

It happens in a small number of cases that the leaflets are wholly or partially abortive, and the petiole is changed into a spine, which is simple when all the leaflets are abortive; trifid, when the two stipules adhering to the base of the petiole, or the two lower leaflets reduced to the middle nerve, harden, forming the two lateral branches of the spines; quinquefid, when the stipules and leaflets are present at the same time. It is in this manner that the spines of different species of *Berberis* appear to be formed, being evidently nothing but leaves reduced to their middle nerve, the bundles of axillary leaves replacing their physiological functions.

The leaf itself may be transformed into a spine in two ways: sometimes it is found reduced to a foliaceous petiole, more or less dilated, and terminating in a spiny point, as appears to take place in *Littæa, Yucca,* &c.; sometimes the limb itself is prolonged into a spine formed by the prolongation of the middle nerve, as in *Chuquiraga.* What I have said of leaves is equally applicable to leaflets, the middle nerve of which is

prolonged into a spine, as in *Coulteria;* to the lobes of leaves which have their nerves prolonged into spines, as is seen in Thistles; and to spiny teeth, which are only lobes smaller than the preceding. The points of the leaves of the Holly come under the class of foliary spines; but those of *Aloe* and *Agave* are analogous to the lateral ones of petioles.

Leaves, reduced to the state of scales, involucra, or bracts, present similar phenomena, and approach, for the most part, petioles devoid of limbs and prolonged into spines; this is readily seen on examining the involucra of the Thistle and other spiny Compositæ.

Peduncles, like all the other organs, may harden at the point so as to become spines. This takes place after flowering, and is presented under two remarkable forms:—sometimes the floral branches, more or less ramified, remain after the fall of the flowers and fruits, and form kinds of spines, usually branched, and apparently terminal, as, for example, in *Alyssum spinosum*, *Mesembryanthemum spinosum*, &c.;— sometimes the axis of the spike becomes indurated after flowering, and is terminated, at maturity, by a hard point, which in certain plants, as *Trifolium subterraneum*, serves, by the curving of the peduncle, to penetrate the earth and bury the seeds there. The pedicels, when they do not bear flowers, are sometimes changed into spines; this appears to take place in *Nauclea*, &c.

The parts of the flower even, though more fugitive than the others, and having consequently less time to harden, occasionally present spiny degenerations.

Thus, the sepals so partake of the nature of leaves that they frequently terminate in spines, as in *Stachys*. The spiny pappi of certain Compositæ come under this class.

The petals themselves, notwithstanding their usually

tender and fugacious nature, are sometimes terminated by spiny points, as in *Cuviera.*

The persistent or sterile stamens of some Byttneriaceæ acquire so firm a texture, that they may take the name of spines.

The styles often remain after flowering, and form at the apex of the fruit spines often very hard and long: as in *Martynia.*

Thus all the organs of plants, except the roots and seeds, are capable of hardening or being prolonged into spines; so that it is impossible to say that a spine is an organ properly so called, but that it ought to be considered a particular state of vegetation.

All thorns which do not result either from the induration or prolongation of any of the organs which I have mentioned, bear the name of PRICKLES, and may be considered as kinds of hairs larger, stronger, and harder than usual. There are cases where the transition from hairs to spines is so gradual as to show their identity of nature: thus, in the bundles of hairs which spring from the axils of the leaves of *Opuntia*, we see some larger than the others, and transformed into very long and hard prickles. It is nearly the same in Roses: we often see the glandular hairs of their peduncles and calyces harden into true prickles. There are cases, then, where there can be no doubt that prickles are analogous to hairs. I know that it cannot be affirmed in a general manner, except by means of analogy.

Prickles are distinguished from spines in their never taking the place of any of the great organs of the plant; they are usually found upon the stems, branches, peduncles, and petioles, and upon the nerves of the leaves, calyx, or even of the petals; but they never terminate either the fibres or nerves; whilst spines, being indurations of organs, are always placed at their ends. This

appears to be the more certain way of distinguishing them, especially in Monocotyledons.

From the prickles replacing hairs, and spines replacing all the other organs, it follows, consequently, that the former are superficial, and the latter intimately connected with the tissue.

It is remarked that most prickles of stems or petioles are curved with the point directed downwards, as in the Rose; but this rule ought not to be taken as a general one, for there exist perfectly straight prickles in several Mimoseæ.

Thorns, whatever be their origin, are generally the defensive weapons of certain plants, serving to protect them from the teeth of large animals, &c. Some, perhaps, may serve either to penetrate the earth to favour the natural sowing of seeds, as in *Trifolium subterraneum;* or to hook the fruits or seeds of certain plants to the wool of animals, in order to transport them to a distance, as in the Burdock.

The existence, and consequently the use of spines, is a fact entirely peculiar to certain species, sometimes to certain varieties, and is but very slightly connected with the general symmetry, and consequently with the fundamental laws of their organization. We frequently observe in the same families and the same genera, species, some of which are furnished with, and others devoid of thorns.

Let us observe, on concluding this chapter (and this remark will be equally applicable to the following), that the analogy which is observed in the manner in which the sepals, petals, stamens, and carpels can, like true leaves, change into spines or tendrils, tends to confirm the identity of origin of these organs.

CHAPTER II.

OF TENDRILS.

UNDER the name of TENDRILS (*cirrhi*), are designated those soft, cylindrical prolongations, which are capable of twisting or twining round bodies they meet with; they are found in different parts of plants, and generally serve to support those which are unable to do so of themselves.

The origin of tendrils is perfectly analogous to that of spines; they are not organs properly so called, but degenerations or modes of prolongation of which almost all the organs are susceptible, and they only differ from spines in their softness, flexibility, and in their usually greater length.

We call those PETIOLARY which are produced by the prolongation of common petioles into flexible filaments; this is frequent in the simply winged leaves of the Leguminosæ, among the Vicieæ, and is met with, though more rarely, in bipinnate leaves, as in *Entada*. In this last case, the common petiole is prolonged into an elongated tendril, and the partial ones either do not lengthen at all, or only present a small, scarcely apparent point. We also find tendrils analogous to simple leaves, but with the segments so distinct that they resemble winged leaves, as in *Mutisia*, and especially in *Cobæa*. Petiolary tendrils are sometimes simple, sometimes branched:—simple, when they are formed by the unbranching pro-

longation of the petiole, as in *Lathyrus Aphaca;*—branched, when this prolongation bears lateral branches, which probably represent the middle nerves of the undeveloped leaflets or lateral segments; this structure is frequent in *Vicia.* When the tendrils are long they readily twine around neighbouring bodies, and serve to support the plants; but sometimes they are so short, as to be unable to perform this office, and only exist as indications of the tendency of certain petioles to be thus prolonged; we see this in *Orobus.* Lastly, the petioles of several Fumariaceæ, although terminated by foliaceous limbs, are frequently twisted at the point so as to act the part, and have the appearance of tendrils. Those of *Clematis cirrhosa,* and some other species, remain after the destruction of the segments of their limb, and form kinds of tendrils.

We know but a very small number of examples of Foliary tendrils, that is to say, of leaves thus prolonged; and these examples also are not of true limbs, but of foliaceous petioles devoid of the limb, and with the nerves, straight or parallel at the base, converging at the apex into a flexible filament; as in *Flagellaria Indica, Gloriosa superba,* and the upper leaves of *Fritillaria verticillata.* If the filament, which proceeds from the middle nerve of *Nepenthes,* and is afterwards prolonged into a cup, can be considered a true tendril, it will approach this class.

Stipulary tendrils are very rare, and even doubtful; we ought to refer, perhaps, to this class:—1st. The filaments which arise from the axils of the cotyledons of *Trapa,* and along the base of its stem. 2d. The tendrils of the Cucurbitaceæ, which occupy the place of a stipule, but are only on one side of the leaf.

Petiolary glands are usually sessile, or nearly so, and but little prolonged; but it sometimes happens that they

are prolonged into slender filaments more or less analogous to tendrils; thus, the glands of the petiole of *Passiflora ligularis* are lengthened into long and nearly cirrhiform filaments.

The petiolary tendrils of *Smilax* are difficult to be understood with regard to their anatomical origin. These climbing shrubs generally have the petiole dilated at the base into a kind of sheath, which might readily be taken for a stipule adhering to the petiole, if the analogy with other Monocotyledons were not opposed to it; above this sheath there proceed from the petiole two opposite, simple, filiform, or elongated tendrils; are they prolonged petiolary glands, as in *Passiflora ligularis?* Their position would appear to make us believe it; but as no *Smilax* bears petiolary glands, this hypothesis is not admissible. Are they prickles prolonged into a filiform appearance? The irregularity of the position of the prickles of *Smilax*, compared with the regular position of the tendrils, ought to clear up this opinion. Are they prolongations of the petiolary sheath? This idea is founded upon the circumstance that they arise from the extremity of it, and it is confirmed by the fact that in *S. herbacea*, which has no sheath, there are no tendrils. Lastly, the opinion which appears to me to be the most likely is, that the leaf has originally three segments, and that the tendrils represent the two lateral ones, which are abortive or transformed. When very young leaves of *Smilax aspera* are examined, it is very difficult not to admit this opinion; it is confirmed by the analogy of the Smilaceæ with the Aroideæ, which often have leaves with several segments.

Peduncular tendrils are more frequent in nature, and clearer as to their origin, than the preceding; they are, as the name is intended to indicate, produced by

the prolongation of the peduncles; this supposes the total or partial abortion of the flowers which they ought to bear. Thus, for example, it is easy to satisfy oneself that the tendrils of the Vine and all the Ampelideæ are peduncles; in fact, we always see that they are opposite the leaves as the bunches are, and it is not rare to find some which are half furnished with flowers and half with tendrils. The little bundles which are found at the upper part of the Vine, frequently present states intermediate between absolutely fertile bunches and those which, by the abortion of the flowers, are changed into tendrils. Analogous facts tend to prove that the tendrils of Passion-flowers are likewise only abortive peduncles, for they occupy their places in the axils of leaves; and in some species, as in *Passiflora cirrhiflora*, the peduncle, which is branched, is partly changed into tendrils and partly furnished with flowers. The pedicels at the base of the scapes of *Cardiospermum*, and of some other Sapindaceæ, are almost always transformed into tendrils. In a species of *Smilax*, several of the axillary peduncles are transformed either usually or accidentally into tendrils, which must not be confounded with those which spring from the petiole.

Bracts and sepals so resemble leaves in their nature, that it is difficult to believe that they are not capable of being transformed into tendrils; the examples, however, of this transformation are rare and doubtful. The floral leaves of *Fritillaria verticillata* change into tendrils very analogous to those of *Gloriosa superba;* the sepals of *Calytrix* are prolonged into a very slender filament, which seems to be the rudiment of a tendril analogous in form to that of *Orobus.* The awns of the glumes of the Gramineæ also appear to be an analogous degeneration; according to Rœper, the glume represents the sheath, and the awn is the abortive limb. They

frequently have a tendency to twist spirally as true tendrils.

Corollas themselves, notwithstanding their fugacity, sometimes take the appearance of a tendril; thus, in the genus *Strophanthus* the lobes of the corolla are prolonged into a fine filament, from one to two inches long in most of the species, and even attaining seven inches in *S. hispidus* of Sierra Leone: the five filaments proceeding from the five lobes are twisted together before the expansion of the flower, thus forming a kind of floral tendril which twines around the neighbouring branches. The tops of the anthers of *Nerium Oleander* are prolonged into kinds of apparently corolline tendrils, which are sometimes twisted together, as those of *Strophanthus.* Thus all the organs capable of changing into spines appear endowed, in other plants, with the faculty of changing into tendrils.

Stems put on this appearance in a great number of cases; and it is usual to call them simply by the name of twining or climbing stems. The annual shoots are the parts which most frequently present this tendency; whence it results, that when the plant is an annual, it is twining throughout its whole life. In perennial plants, two cases happen:—the stem either constantly remains in the same twisted state as it was in during the first year, as in most Passion-flowers; or, the lower part becomes so firm as to be able to support itself, and then we have a shrub with an erect stem and twining branches; this is observed in several species of *Convolvulus.* The reverse takes place, according to Vaucher, in *Periploca Græca,* which scarcely twines the first year, but afterwards very strongly encircles trees which it meets with.

The transformation of organs into spines supposes in general the existence of a hard and solid fibrous tissue; therefore this texture is more or less remarkable in all

spiny plants. The transformation into tendrils supposes, on the contrary, a soft, flexible, fibrous tissue, capable of elongation; therefore we remark in each family, that those plants, in which the stem has a tendency to be prostrate or climbing, have at the same time and for the same reasons some organs transformed into tendrils. The Vicieæ, Mimoseæ, Passifloreæ, Sapindaceæ, and Smilaceæ, with weak stems, have well-developed tendrils; whilst in the same groups we find no tendrils, or only rudimentary ones, where the stem is stronger; thus *Orobus* and *Faba*, which have a firm stem, are the only Vicieæ which are almost devoid of them; none of the Mimoseæ with strong stems have any, whilst *Entada*, which has twining stems, is furnished with them; the arborescent Passifloreæ are alone devoid of them; the weak and climbing Sapindaceæ only, as *Cardiospermum*, *Urvillea*, *Paullinia*, are furnished with them; *Smilax herbacea*, which has an erect stem, is devoid of them, whilst all the other species are provided with them. Thus it is generally found that tendrils are only developed in plants too weak to support themselves. The existence of this kind of support enables them to twine round trees or shrubs; therefore most plants of this kind live, in preference, in forests when they are very large, and among bushes and hedges when small. The farmer imitates this natural phenomenon when he sows Vetches among Oats, which serve to support them.

The twisting of twining stems and tendrils takes place in each species in a determined manner—either crossways or spirally; the former is performed upon the same plant, and only takes place in tendrils which find no other body to lay hold of: this is frequently seen in Sapindaceæ. The twining in a spiral manner, properly so called, always takes place in stems or tendrils which are twisted around a long body. What is most remark-

able is, that in each species the direction appears to be strictly fixed, viz.—from right to left in the French Bean, from left to right in the Hop. *Bryonia* presents in this respect a phenomenon of which I know no other example; its tendril suddenly changes its direction in the middle of its course, so that the upper half twines in a contrary direction from the lower. The causes which determine the twining in general, and the particular direction, are very imperfectly known, and purely physiological.

CHAPTER III.

OF FASCICULATED EXPANSIONS.

All the caulinary organs, which are not expanded into foliaceous or petaloid limbs, have a tendency, in certain constant or accidental cases, to form kinds of expansions of a singular nature, and which I call Fasciculated Expansions, extending a little the ordinary use of this term. In these expansions, the branches, peduncles, or petioles, instead of being cylindrical, become spread out, and, as it were, semi-foliaceous, the fibres or nerves remaining either nearly parallel or converging, or diverging towards the apex, but nearly simple, and not expanded as in the limb of leaves. It might be said that in this mode of vegetation, the fibrous bundles, usually arranged

in such a manner as to form a nearly cylindrical body, spread out at the base, arranged side by side so as to form an expanded disc; and in certain cases, one would be inclined to believe that the fasciculated expansions are produced by the natural union of several small branches which arose, side by side, from the same point. There is no doubt that this happens sometimes, but it would be imprudent to affirm that it is the only cause of these expansions.

Branches are very subject to this unusual kind of development; the fasciculated branch or stem is nearly cylindrical, afterwards it becomes flattened, more or less striated or channelled longitudinally; near the extremity the small portions separate by the striæ having a tendency to separate from each other, and frequently form as many small branches situated nearly upon the same plane; when they do not separate, they frequently present the appearance of nerves united by cellular tissue. Almost all vascular plants may accidentally present this phenomenon; thus I have observed it among herbaceous Dicotyledons in *Ranunculus*, *Euphorbia*, *Cyparissia*, *Chicorium*, *Jasione*, the Cockscomb, some species of *Stapelia*, &c.; among woody ones in *Daphne Mezereum*, the Jessamine, Ash, Broom, (Pl. 4, fig. 1,) &c.; and among Monocotyledons in *Asparagus*, and also in some Ferns.

If it were always accidental, it would possess little organographical interest; but it is sometimes presented under an appearance so constant, that it seems to form part of the ordinary state of plants; this appears to be the case in *Xylophylla* (Pl. 16, fig. 1.)

On examining the nature of plants capable of forming these expansions, we see them either much branched, or furnished with a very abundant cortical cellular tissue—two circumstances which tend to confirm the hypothesis

that they result from the union of several neighbouring branches upon the same plane.

Fasciculated stems must not be confounded with stems or branches which have the cortical parenchyma so extended upon their two opposite sides as to give them the expanded appearance of a foliaceous limb; thus, several species of *Cactus*, as *C. Phyllanthus* and *Opuntia*, have the branches expanded laterally into a limb which has a leaf-like appearance. *Ruscus aculeatus* (Pl. 16, fig. 3,) also presentsw inged branches, which have exactly the appearance of a true leaf. In these different cases, we recognise their true nature either by studying the origin of the organs, or by following their development; when they begin to enlarge, the woody body, by distending the bark, gradually obliterates these foliaceous appendages, and the winged branches are changed into cylindrical stems.

CHAPTER IV.

OF DEPOSITS OF NOURISHMENT, OR THE FLESHY, FECULENT, ETC. DEGENERATIONS WHICH MODIFY THE TEXTURE OF ORGANS.

In the same manner as some organs, taking a more ligneous texture than ordinarily, may be changed into thorns, and thus become the defensive arms of the plant; so there are other parts which, acquiring a considerable thickness, receive into their tissue a large quantity of watery, mucilaginous, feculent, or oily

matters, and are then found to become deposits of nutriment for a given period or a given part of plants. The organs thus modified are the more important to study, since they perform a considerable part in the nutrition of plants, and often produce phenomena apparently contradictory to the progress of the sap. In fact, if it be true, as vegetable physiology appears to demonstrate, that the sap is only elaborated in the foliaceous parts, and only becomes a nourishing juice after this elaboration, how can we understand the nutrition of a great number of organs which can receive no action from the foliaceous parts, and which are evidently nourished by the ascending sap?

The cellular tissue of several very different organs is capable of being dilated, and of receiving a much larger quantity of water than usual; it is this which constitutes the ordinary state of the leaves of succulent plants, that of several fleshy roots, that of succulent pericarps called fleshy fruits, that of fleshy spermoderms, &c.

The nature of the water accumulated in the tissue presents differences, both between one organ and another, and one plant and another: thus, the water which swells up the leaves of several Ficoids contains earthy and alkaline salts in solution; that which is in most fruits contains mucilaginous or saccharine matters, &c.

The tendency of each organ to a state of anasarca is sometimes constant in the species, sometimes accidental. Thus, the leaves of Ficoids, Crassulaceæ, Portulaceæ, Aloes, &c. the stems of the Cacteæ, *Stapelia*, &c., and the perigones of *Blitum*, are constantly fleshy. The pericarps of a great number of plants also present this disposition in a permanent manner. In all these cases we remark that this state is connected with the total absence of the stomata when it affects fruits, or with their small number when it affects leaves.

But this state, constant in certain plants, is met with accidentally in others evidently caused by external circumstances; thus *Lotus corniculatus*, Plantains, and several other plants, have leaves more fleshy than usual when they grow near the sea.

It results from this disposition in leaves, that they become receptacles of water, and the plants, thus organized, can consequently support drought much better than others, since they then reabsorb the water of their leaves. Thus eminently succulent plants, as the Ficoids, can support the long drought of the African deserts by a phenomenon nearly analogous to that which enables camels to travel for a long time in the same regions.

As to fleshy pericarps, it is not easy to determine the use of this particular state to the plant. Does this deposit of juices, gradually absorbed by the plant, serve to continue the nutrition of the seeds until their maturity? Does it serve, by decomposing it, to favour their coming out of the pericarp, which in fleshy fruits is always indehiscent? Does it serve, at this period, as a kind of manure to nourish the germinating seeds? All these opinions are evidently true in certain cases.

It is rare to see pericarps pass accidentally from a dry to a fleshy state, or *vice versâ*. We can mention a small number of examples; such as that singular kind of the Almond-peach which sometimes bears upon the same tree fruit with a fibrous pericarp, and others with a fleshy one. But we know a host of examples where plants, very similar in structure, differ in the dry or fleshy nature of their pericarp; such are the Almond and Peach, *Silene* and *Cucubalus*, *Hypericum* and *Androsœmum*, &c.

The deposits of mucilaginous and feculent matters are as frequent as the preceding; they may be found in all

the organs of plants, and their presence determines the possibility of the development of certain parts. In fact, without this deposit prepared before-hand, it would be impossible to understand how certain ascending parts are nourished until the period when their own nourishing organs are developed, or how certain parts are developed although apparently devoid of proper organs to elaborate the ascending sap.

If I form a just idea of this phenomenon, which is in itself very remarkable, this is how I understand it: the watery sap or lymph absorbed by the roots passes through the cellular tissue essentially by the intercellular passages, as Kieser and others appear to have clearly demonstrated; when it passes into the canals or passages which separate the very long cellules, which are usually empty, it follows its course without any alteration; when it traverses the organs abundantly supplied with round cellules, its motion nearly ceases, or is very slow, and then another phenomenon may take place: if the progress of the vegetation of the preceding year has accumulated in these cellules a certain quantity of mucilage, this is partly or wholly dissolved in the lymph which surrounds the cellules, and when, by the development of the upper parts, this lymph is attracted there, it does not arrive in the state of pure water, but it contains a certain quantity of mucilage in solution.

I think that the same takes place with regard to feculent or oily matters, although we do not possess, especially as concerns the former, any correct ideas of the manner in which they can be affected by the water so as to become soluble in it. Although we do not know how to render fecula or starch soluble except by processes hardly likely to be met with in vegetation, it is, however, certain that it becomes so by the force alone of vegetable life, and the history of the germination of

Wheat is an example. It appears to me that an analogous phenomenon evidently takes place when the lymph traverses a feculent or oily deposit.

If we now apply this general idea to all the cases where certain organs are nourished without the possibility of their being so by the descending sap, we shall see that they owe it to deposits prepared before hand in the course of the ascending sap.

Thus, in all perennial plants, mucilaginous or feculent matters are deposited, towards the end of summer, in the upper parts of their roots: when the new stems shoot up in spring, they are nourished by the ascending sap, which, in passing through these nutritious deposits, dilute them, and, becoming charged with them, carry them to the parts destined to be developed until the production of leaves allows them to prepare their own nourishment. Tuberous roots present, in this respect, special organs for the deposit of these matters, and we see that they are destroyed after the development of the young shoots: this is also applicable to subterranean stems and tubercules, as well as to the nodes of ordinary stems from which we see the young branches produced.

In dicotyledonous trees the pith is a true deposit of nourishment as regards the young shoot, and we see it dry up and perish after it has fulfilled this office.

The receptacles of several flowers serve the same purpose; before flowering, they are found loaded with mucilaginous and feculent juices, which are carried up by the ascending sap during flowering, and serve to nourish the flowers and fruits; after this period, they become empty and dry up, as may be seen in the Artichoke, &c.

What we have clearly seen in those receptacles, which are very large, and nourish a great number of flowers, takes place in all peduncles, but in a more or

less visible manner: thus, for example, the centre of the rays of umbels is a point where a deposit of nourishment is effected, and from which the flowers draw their supply. In all cases flowers are developed by the ascending sap, which, in its passage, meets with deposits prepared beforehand by the action of the foliaceous organs.

The placentæ of fruits enjoy the same function with the greater energy as they are thicker or more fleshy: thus, in several Solaneæ, Rubiaceæ, Primulaceæ, &c. in *Cobæa* and a number of others, they are true deposits of fecula, which serve to nourish the seeds.

Finally, cotyledons themselves are often fleshy, and then become true deposits of nourishment prepared by the mother-plant, and absorbed by the embryo at germination.

All that I have said of the deposits of mucilage and fecula is equally applicable to those of fixed oil situated either in the pericarp, as in the Olive, in the albumen, as in the Euphorbiaceæ, or in the cotyledons, as in the Poppy.

Thus, all the organs of plants are, in certain cases, capable of performing a particular physiological function, in becoming depositories of nutriment prepared for different growing organs; but this circumstance, which alters their use, ought only to be considered with regard to Organography as a particular modification or degeneration. It is in this point of view that I have here spoken of the subject, which will be treated of more in detail in the Physiology.

CHAPTER V.

OF SCALES.

We generally designate under the name of Scales *(Squamæ)* the little flat pointed bodies which are found upon different parts of the surface of plants; but there are few terms under which more dissimilar objects have been confounded; the simple mention of them will be sufficient to make their differences understood, and to show how we must distrust, in natural history, those vague denominations which are not founded upon anatomy.

The organs confounded under this name may be referred to three principal classes:—appendages analogous to hairs;—excrescences of certain organs;—and foliaceous organs more or less abortive and reduced to a rudimentary state.

Scales analogous to hairs are:—either kinds of radiating and peltate discs, as those of *Elæaguns* (Pl. 3, Fig. I.) which seem formed by the constant union of several hairs radiating upon the same plane; or of enlarged hairs, scarious and dilated at the base, as those on the petioles of Ferns. These appear, at first sight, to differ much from hairs; but if they be studied in the whole family, every degree of size is met with, from those which are entirely in the form of hairs, to those which are large and dilated into scales. The membranous expansions which crown the fruits of several Com-

positæ and some Dipsaceæ, may be considered either as the hairs of pappi united together, or as membranes formed by a greater abortion of the limb of the calyx than ordinary.

The second class of scales are the expansions peculiar to certain organs; thus, the calyx of *Salsola* bears upon its back membranous appendages which form part of that organ, the throat of *Nerium Oleander*, *Silene*, &c. is prolonged into petaloid scales which collectively form a kind of crown; these different bodies, whatever their origin, are not special organs, but simple forms peculiar to such or such a part.

Lastly, the most frequent sense of the word scale is to designate small flat bodies which are the rudiments of abortive leaves or analogous organs, such as stipules, bracts, or sepals, or even of the other floral organs reduced to very small dimensions. This degeneration changes their form and appearance, and causes them not to be recognised by those who are not acquainted with this kind of change. Examples taken from the different organs will suffice, I think, to make me understood.

It is customary to say, that the calyces of Pinks are furnished with four scales at their base; but whoever will examine them with care, will perceive that they are only the upper leaves or bracts, which from being near the flowers, remain very small, and have taken the appearance designated in other cases by the term scales.

The branches of most of the Erythroxyleæ, of *Pictetia squamata*, and several other plants, are often invested with little imbricated and scarious scales, which are persistent and very close stipules, the leaves of which are wanting.

The bracts which form the involucra of the flowers of the Compositæ and Dipsaceæ are leaves reduced to small dimensions, and for this reason have received the

name of scales. This name is also given in the same plants both to the abortive bracts situated between the flowers, and more usually called PALEÆ, and to the pieces of the calyx, reduced to the state of pappus, when their form differs from that of hairs, and their texture gives them a rude resemblance to scales; it is also in this sense that this name has been given to the bracts of cones, to the glumes of several Gramineæ and Cyperaceæ, &c. &c. Lastly, the scales of buds come evidently under the same class, and are only the rudiments or abortions of leaves, petioles and stipules; but their history is so important that it deserves particular mention, and therefore I dedicate the next chapter to it.

CHAPTER VI.

OF BUDS.

THE term BUD is taken, in the French language, in two very different senses. 1st, the young productions or branches of perennial plants are commonly meant by it. Botanists call these YOUNG SHOOTS or SCIONS (*turiones*). When these shoots are found covered or protected in their infancy by particular scales, the plant is said to have scaly buds; in the contrary case, they are said to be naked. 2d, Botanists, on the contrary, designate by the name of BUD (*Gemma*), not the young shoot, but the collection of scales or coats which surround and

protect it in its infancy; in this sense, which we shall adopt here, they say that a young shoot is naked, or without buds, when at its development it has no particular integument; they say that it has a scaly bud, when it presents an integument formed of pieces analogous in texture to scales; and they may also say that it has a bud with membranous coats or fleshy scales, &c.

Gardeners are also accustomed to call by the name of bud both the flowers, as yet undeveloped, and the buds (in the sense of botanists) before their expansion; but botanists have admitted the name of ALABASTRUM to designate the unexpanded flower: but let it be remarked that, throughout this chapter, we restrict the name Bud to the integuments of the young shoots at whatever age we examine them.

Buds present very different appearances according to the place they occupy, and according to the nature of the plant: we shall distinguish in this respect two classes, viz. 1st, caulinary buds, which grow upon the stems of trees and shrubs, or the buds, properly so called; 2d, those which are formed at the neck of perennial plants, on a level with the surface, as scions, or underground, as bulbs properly so called.

The origin of these two kinds of buds is always a semi-abortion or degeneration of the foliaceous parts, but their position produces such great changes in their appearance, that it will be better to study them separately at first, and afterwards to show their points of affinity.

All Dicotyledonous trees have not their young shoots covered with special integuments; and these integuments themselves, when they exist, proceed always from external leaves or stipules, which, on account of their premature exposure to the action of air and light, suffer

in their development, and are more or less completely changed into scales. When we examine the structure of a bud of the Ash or Sycamore in spring, we see the external scales short, hard, of a reddish brown colour, and slightly downy, and the inner rows gradually become more membranous, paler, and longer; afterwards they bear at their extremity the rudiments of leaflets; then they become small leaves, so that it is impossible to doubt that the external pieces are of the same nature as the internal.

Buds have received particular names, according as they are formed by different portions of the foliaceous organs, and according to the degrees of their degenerations and adhesions.

1st. We say that buds are FOLIACEOUS when the leaves being sessile, their limb, reduced to the form of a scale, forms the buds, as in *Daphne Mezereum.*

2d. Buds are said to be PETIOLACEOUS when the bases of the petioles, dilated into scales, form the covering of the young shoot; this is seen in exstipulate petiolate leaves, as the Walnut, the Ash, the Horse-chestnut. (Pl. 12.)

3d. STIPULACEOUS buds are those which are formed, not by the leaves, but by the stipules, which are not united to the petiole. We distinguish two kinds of stipulaceous buds: 1st, those which are formed by the superposition of a great number of stipules which together inclose an entire young shoot; this happens in almost all the Amentaceæ, as the Oak, Willow, Elm, &c.; 2d, those, the stipules of which, free or united together by their outer margin, form the peculiar envelope of each leaf, and are gradually developed with the branch itself; this is seen in *Ficus*, (Pl. 6) and the Magnoliaceæ; these kinds of monophyllous buds can be recognised at first sight by their

terminating the branch in the form of a very sharp cone.

4th. When the stipules adhere to the petiole, these two organs, united into one, form the scales of the buds, which are then called FULCRACEOUS; this happens in most Rosaceæ; these kinds of scales frequently have three lobes or teeth, which indicate the origin of the scale, formed by the petiole and the two stipules united together. (Pl. 15, figs. 4, 5, 6.)

Monocotyledonous trees, or palms, have buds exactly resembling the preceding as to their origin; they are of the petiolaceous class: it may be said that the tops of *Dracæna*, and other trees of this kind, have foliaceous buds; but these are the only classes of buds which can be found among Monocotyledons, because the stipules are wanting here, and, consequently, stipulaceous and fulcraceous ones are impossible to be met with.

In perennial herbs the shoots perish each year, or at least after each flowering, and new ones are developed, which spring from the permanent part of the stem underground, or on a level with the surface, and which is usually confounded with the root. These new shoots often proceed from buds which are named TURIONES, which, considered as to the origin of their scales, present the same varieties as the buds of trees. Thus, in Dicotyledons, we may say that foliaceous turiones are met with in Asters, petiolaceous ones in Pæonies, (Pl. 15, figs. 1, 2, 3,) and fulcraceous ones in *Potentilla*. I do not know any example of purely stipulaceous turiones, for all of the families furnished with them have only herbaceous species; but their existence is not improbable, and it might be said that *Salix herbacea* has them when its stem is subterranean.

Among Monocotyledons it may also be said that the scales of the bulb of the Lily are simple leaves, which

from being underground are etiolated and fleshy, and come under the class of foliaceous buds; whilst the radical buds, produced by the dilated petioles of *Hemerocallis*, are examples of petiolaceous ones. We know that in this class we can find none of those which suppose the existence of stipules.

Although aerial and subterranean buds have the same origin, the difference of their position produces diversities in their nature, which deserve to be analyzed.

Aerial buds owe to their position the peculiar texture of their scales, which, exposed to the action of air and light, evaporate much, and are found reduced, as it were, to their fibrous tissue. These characters go on diminishing in the inner scales, which from the same circumstance evaporate less, and retain the juices more.

The buds have eminently two uses to perform—to defend the young shoots from damp and cold.

In the first respect the scales are generally so numerous and applied to one another so exactly, that the rain cannot penetrate their interstices before their expansion. Several buds present, moreover, a particular protection against moisture, in having their scales covered over with a varnish or viscid layer of a resinous or waxy nature, which is not miscible with water, and thus prevents its introduction. The buds of the Horse-chestnut present this in a high degree; those of the Alder and Black Poplar are also invested with a resinous matter, which defends the young shoots from moisture.

With regard to temperature, the superposition of the scales is a means of protection from cold, because each of them incloses a certain quantity of air; moreover, several buds are invested externally with a close down, and some have the inner cavity full of a soft thick down

resembling cotton, which surrounds the young shoots, and protects them, like fur, against frost, and also a little against moisture. The buds of the Horse-chestnut are also examples of this structure. There are some shrubs, as a species of *Viburnum*, where, according to Kœler, the scales are wanting, and are replaced by a cloth-like down.

It is on seeing this important character of buds, and comparing their existence in different plants, that we have been led to conclude that trees devoid of scaly buds cannot live in cold climates, and that those of warm countries can only be acclimatized in the north, which are furnished with them. These two rules are generally true, but they are subordinate to the peculiar nature of the leaves of each species, and both present exceptions. Thus, *Viburnum Lantana* and *Rhamnus Frangula*, although natives of cold countries, have no scaly buds; and Palms, though furnished with petiolaceous buds, cannot exist in the north.

It would be curious to follow the vegetation of trees of species like our own in very different climates, in order to know—1st, if the outer leaves of the young shoots continue to be changed into scales, when the trees are placed in a warm and very fertile climate? 2d, if certain trees, which in such climates do not present this transformation, would not be liable to undergo it in less warm climates, and if they could not be induced to do so by culture? If these two questions could be answered in the affirmative, the field of naturalization would be found greatly extended.

The buds of trees usually proceed from the axils of the leaves, and consequently the disposition of the young shoots is determined by that of the leaves; but of the buds which are developed, a great number sooner or later become abortive, whence it results that the branches

of trees are frequently irregular, although they were originally disposed in regular order.

Besides the buds evidently axillary, certain trees present terminal ones, which are generally larger and more forward than the others; they are met with in trees both with opposite and alternate leaves. In the first case three buds grow at the top of the branch, viz. the terminal one, and the two which are produced in the axils of the upper leaves: these three are rarely developed together; the two lateral ones are sometimes abortive, and the terminal one alone is developed, as in the Horse-chestnut, *Pavia*, the Sycamore, &c. Sometimes the terminal one is abortive, and the lateral ones are developed, whence a bifurcation results, as in the Lilac. The same differences take place in trees with alternate leaves. Thus, the terminal bud continues the branch in the Holly, Oak, Peach, &c.; it is absent or abortive, and the branch is continued by the buds of the upper axils in the Apricot, Rose, Hazel, &c.

The development of the buds of a branch in spring commences almost always at the apex, and proceeds downwards, so that the lower buds are the last to shoot, and sometimes are not developed. This appears to result from the upper part being more herbaceous, and consequently more sensible to the action of the warmth of the atmosphere; whence it results that an equal degree of warmth applied to a whole branch has a greater action upon each bud in proportion as it is nearer the top. The exceptions even confirm this rule; for in the trees where the branches are of an equal degree of hardness, or, as gardeners say, equally ripened throughout, the buds follow the contrary order of development, being influenced by the ascending sap; as in the Larch, *Gincko*, &c.

The buds of Dicotyledonous trees differ from one

another according to the nature of the young shoots they are destined to protect: some inclose branches furnished only with leaves and devoid of flowers; these are called LEAF-BUDS: the others contain only bunches, umbels, or heads of flowers, and are called FLOWER-BUDS; some contain, at the same time, leaves and flowers, and for this reason are named MIXED BUDS. The first are generally recognized by their long pointed form; the second, by being round; and the last, by an intermediate form. It is evident that the distinction between leaf and flower buds is only possible in trees where the flowers arise independently of the leaves, as in the Cherry, Apple, &c., and that the mixed buds are the only ones which can be found in the trees where the flowers grow upon the same branches as the leaves. In the first, the position of the two kinds of buds is determined beforehand, and the period of development of each frequently disturbs the usual order of their evolution from the top to the bottom.

As to the young shoots which proceed from each bud, the development takes place from the base upwards, to whichever class they belong: the scales of flower-buds ought to be considered as the rudiments of bracts, and in many respects these buds might be compared to involucra; there are really no other differences than that the floral buds are usually caducous, whilst involucra are ordinarily persistent: but there are many intermediate cases in duration and appearance; thus the envelope which surrounds the flowers of *Cornus mascula* and *Aucuba* is sometimes called bud, at other times involucrum, and both terms are, in fact, equally applicable to it. We might very well say, that the head of flowers in the Compositæ and Dipsaceæ is a kind of bud.

When the petioles of trees are dilated at their base into a sheath, this surrounds the young shoots and often

acts the part of a bud; sometimes it surrounds it so completely, that no bud is perceived in the axil, but it appears lodged in a cavity of the petiole formed by the two edges of the sheath folded upon one another. This is seen very clearly in *Smilax aspera*, where the petiolary sheath surrounds the young shoot, and remains upon it until the spring. We meet with an analogous and still more singular fact in the Plane; here the leaves fall off in the Autumn, so that the bud is not protected as at its first development: the margins of the petiolary sheath are completely united together so as to seem to inclose the bud; but if we make an examination just before the fall of the leaves, we see that the base of the petiole is split longitudinally on the upper side, exactly at the place where the theory indicates that the two margins of the sheath ought to be found. Phenomena analogous to the preceding are met with, with slight variations, in *Negundo*, *Philadelphus*, *Robinia*, and some species of Sumach *(Rhus)*.

The buds which are developed in perennial herbs, either on a level with the surface or under ground, differ the more from aerial ones, in proportion as they are more decidedly subterranean. The more a vegetable surface is deprived of the action of air and light, the paler will it be, the less will it evaporate, and consequently it will take, according to the texture of its organ and the period of its vegetation, either the appearance of a simple membrane, or that of an etiolated body, but, however, full of juice.

If we compare the aerial buds of the tree Pœony with those at the neck of the herbaceous ones, (Pl. 15, Fig. 1, 2, 3,) it will be impossible to perceive any other differences between them than those which result from their position; and all the turiones, or buds on a level with the ground, in perennial non-bulbous plants, hardly

present any other differences; but they usually take the name of BULBS *(bulbi)* when they present certain peculiarities which deserve to be studied.

1st. A small number of Dicotyledons, which are called bulbous, have received this term from a double peculiarity of their organization, viz., that their leaves have a petiole flattened at the base, more or less sheathing, and their stem is swollen up above the neck into a kind of tubercule; it results from this, that this tubercule, covered by the petiolary sheaths, resembles the bulbs of several Monocotyledons; such is the structure of *Ranunculus bulbosus*, *Fumaria bulbosa*, &c.

2d. Several Monocotyledons present an analogous disposition, that is to say, they have the leaves sheathing at the base (which is frequent in this class), and at the same time the base of the stem is swollen into a tubercule, as in several Irideæ, whence results a kind of bulb, which many naturalists call a BULBO-TUBER.

3d. True bulbs present a very short subterranean stem, reduced almost to a simple plate; from it the leaves arise in great numbers, overlaying one another, and thus forming an oval or round body; the external leaves are reduced to the state either of fleshy scales, as in the Lily, and then the bulb is said to be SCALY; or of short truncated membranous sheaths, as in the Hyacinth, when it is said to be TUNICATED. In these last the base of the sheaths, and especially that of the inner ones, is fleshy, as in the scales of the Lily, and approaches them in texture although distinct in form. The inner sheaths have a tendency to elongate into true leaves, and all the radical leaves of the Liliaceæ are prolongations of the inner pieces of this bulb. An Onion of the first year is nothing but a terminal bud, situated at the top of an extremely short subterranean stem.

When this organization is compared with that of a

Palm, we shall find, in this respect, that there is no other difference but that the stem of the Palm is very long, and, consequently, bears its bud very high, whilst that of the Tulip is very short and leaves its bulb to be developed under ground. Every intermediate state is met with in species of the same class; thus, we see the stem take a greater elongation in certain species of *Allium*, *Crinum*, *Yucca*, *Dracæna*, &c.; and we thus arrive by insensible degrees from the scarcely visible stem of bulbs to the long ones of *Yucca*, from the subterranean buds of the Liliaceæ to the aerial ones of Palms: we understand, then, how it happens that in the same class there are sometimes very visible stems without true bulbs, and sometimes bulbs without there seeming to be any stem.

What are called Offsets are nothing but the axillary buds of bulbs, or in other terms, the young branches which are developed in the axils of the leaves; they present this peculiarity, which probably results from their position, that they are only attached to the stem by a slender filament which is easily broken. As they have their scales fleshy and full of nutriment, they can be developed by themselves as tubercules; and this frequently happens when they are separated, either artificially or naturally, from the mother plant. The buds of Dicotyledons, detached from the tree, may vegetate, provided they are placed, by the operation of budding, in a similar situation; those of bulbous Monocotyledons carry with them sufficient nutriment stored up to enable them to continue to grow, especially where they find heat and moisture.

We may distinguish in bulbous plants, as in trees, leaf-buds, flower-buds, and mixed-buds; thus, most species of *Amaryllis* have at the same time the two first, and the Tulip the last.

What is remarkable in bulbs compared with buds is, that their coats remain for many years: so that a bulb is not only formed of the buds of the year, but of the sheathing coats of preceding years, which are then exhausted of all nourishment, but remain under the form of membranes, and thus serve to protect the young offsets either from cold, because they contain several strata of air between their coats, or from wet, because their epidermis is silicious and scarcely affected by moisture. There are some bulbs which, like the buds of trees, present a cottony layer between or outside their coats, as in the Tulip.

It results from all that I have set forth in this chapter, 1st, that buds are the integuments of the young shoots formed by the external foliaceous organs, sometimes in their natural state, as the stipules of *Ficus* and *Magnolia*, but most frequently converted into scales by a kind of degeneration or semi-abortion caused by their position; 2d, that the buds of trees, exposed to the air, and those which spring on a level with the surface, or the turiones of perennial plants, and subterranean buds, or the bulbs of the Liliaceæ, &c. only differ from one another in what must necessarily result from their position, and the stems which bear them.

BOOK V.

CONCLUSION, AND GENERAL CONSIDERATIONS.

After having described all the organs of plants, and having nearly come to the conclusion of this Work, I ought now to give some general considerations, which might have appeared either too hypothetical if I had treated of them at the commencement, or too misplaced if I had dwelt upon them occasionally. I shall proceed to point out those general subjects which are as much connected with Physiology as Organography.

CHAPTER I.

OF THE INDIVIDUAL PLANT.

What in the vegetable kingdom ought to be considered as an Individual?

Illiterate, and even educated persons, accustomed to see all the higher animals endowed with a life of their own, have with difficulty believed that all which is presented under an analogous appearance can present really different phenomena; and have had much greater difficulty in forming an idea of beings, in appearance simple, but in reality an assemblage of individuals. They have expressed great surprise when zoologists have shewn that there exist apparently simple animals, but which, in reality, are composed of several beings collected together, living, however, with a common life: such are the Botryllæ, Pyrosomæ, Polyclinums, and probably the fresh-water Hydras and Polypes. Passing to the vegetable kingdom, the question is whether plants are single individuals, as vertebrate animals, or individuals collected together, as the Polyclinums.

The common opinion is, that a Willow, Cherry, Cabbage, &c. are so many single individuals; but when we examine them, we find that they are singularly divisible: almost all their parts are capable of being separated from the whole, and of forming a new individual. This division can go on *ad infinitum;* and there are examples, such as the first Weeping Willow introduced into Europe, (I select this example, because we only possess one

of the sexes, and that does not seed,) from which, by simple division, all the Weeping Willows existing in Europe have been produced: all of these, then, are portions of a single individual. The word individual, taken in this sense, will be still more incorrect than if we considered a mountain of granite as a mineralogical individual, divisible, at the will of man, into as many fragments as he might reduce it to by breaking the rocks.

Do we say that we only admit as distinct individuals those plants which proceed from a seed? This would be an approach towards correctness; for it is certain that plants produced by simple division retain all the peculiarities of the one of which they made part; whilst those proceeding from seeds may present varieties or differences, and seem to maintain in preference that which forms the type of the species.

But how can trees which proceed from division, or from seed, be distinguished when they are alike? How can this line of demarcation be drawn between this multitude of beings, when we cannot distinguish seeds from bulbs or spores? How can this possibility of division, *ad infinitum,* of an individual, supposed to be single, be admitted? How can this definition be reconciled with analogies elsewhere so remarkable as we have observed, in the course of this work, between germs capable of being developed either with or without fecundation?

All these difficulties vanish, on admitting that plants, such as they appear to our eyes, are almost all aggregations of individuals, and not single individuals. Although allusions to this opinion are met with in several authors, and particularly in the writings of Goëthe, Mr. Darwyn, on commencing his Phytologia with a chapter on the individuality of buds, appears to me to be the first who expressed it in general terms.

We consider, then, as an individual every developed

germ, viz.; 1st, sometimes a seed, supposing that, as takes place in some annual plants, it produces a stem without branches; 2d, sometimes a branch considered as a developed germ. Thus, in this sense, a tree is an aggregation of the primitive individual proceeding from the seed, and of all the individuals proceeding from unfecundated germs which are developed one upon another, and have formed the prolongations or ramifications of the primitive individual.

Cassini opposes this idea, and persists in the opinion of the unity of the plant, founding it upon the continuity of the fibres of the branches and of the trunk; but this continuity only proves, which no one can deny, that the germs spring from the extremity of the fibres: in other cases we find a continuity equally as great, at least from our means of investigation, when we dissect a branch proceeding from a grafted bud; for, in this case, we know perfectly well that there is a plurality of individuals and continuity notwithstanding. I do not think, then, that the observations of this learned botanist can modify the theory of Darwyn.

Each branch, or partial individual, presents great conformity of development with the primitive individual; its pith, full of juice, acts the part of a reservoir of nutriment; and in Dicotyledons the two first leaves of each branch are almost always opposite like the cotyledons which they seem to represent.

Each partial individual, whether it originate from a seed or from an unfecundated germ, is susceptible of two kinds of terminations:—it is sometimes terminated by a flower; sometimes it is prolonged without flowering, and only seems to stop from defect of nourishment. The indefinite development of a branch requires more vegetative force, and is more frequent in young plants, and in those growing in very damp situations. The termi-

nation of a branch by a flower is more frequent in old individuals and in those which have but little watery nutriment. The indefinite development of branches which do not flower favours the production and growth of a great number of nutritive leaves, which tend to increase the force of the aggregate, and to deposit here and there stores of nourishment adapted to favour new developments of germs or flowers. The termination of branches by one or more flowers tends to deprive the branches or trunks of the development of nutritive organs, and to consume the deposits of nutriment which may exist in the branches, stems, or roots.

When the flower only consumes the nutriment contained in its peduncle or immediate support, these dry up after flowering in the male flowers, and after the maturity of the fruit in the females. But as the rest of the plant has not been exhausted, it continues to vegetate, maintained by the branches which have produced nutritive leaves, and the following year new germs are developed. In this manner are formed trees, shrubs, and under shrubs, or, in one word, all CAULOCARPIENT plants.

When the flowers are more numerous in proportion to the force of the stem which bears them, they exhaust, during the maturation of the seeds, not only the nourishment deposited in their peduncles, but also all that of the stem, which then perishes nearly down to the neck; and the following year the new buds arise from the persistent part or stock; this happens in perennial herbs, or RHIZOCARPIENT plants.

Lastly, if the flowers be still more numerous, or require a greater quantity of nutriment in proportion to the force of the stem which bears them, they exhaust, during the maturation of their seeds, not only their peduncles and stem, but also the root; then, after the maturity of

the pollen in the male plants, or the seeds in the females, the whole plant being exhausted dries up and perishes: this forms plants said to be Monocarpient; that is to say, those which fructify but once at the end of one year (annuals), of two years (biennials), or of several years, as for example in *Agave*, &c.

These differences, although constant in each species, since they are determined by causes inherent in its structure, are nevertheless subject to modifications from external circumstances. We can transform an annual plant into a perennial one by preventing it from bearing seeds; thus, the Mignionette has been changed into an under-shrub which, when once it has a woody stem, flowers each year, without the exhaustion produced by the flowering causing the stem to perish; thus the double Nasturtium has become perennial, because its flowers, devoid of the faculty of producing seeds, do not exhaust the stem; and it is probable that every annual plant, which may be rendered double by culture, will become perennial.

We may likewise transform, in an analogous manner, a perennial plant into an under-shrub; this is frequently the case in double pinks. *Zizyphus* presents a curious phenomenon which renders it, as it were, intermediate between Rhizocarpient and Caulocarpient plants; we see upon its old trunk kinds of exostoses, from which proceed several simple branches, of which those which bear a great number of flowers disarticulate, and fall after flowering, exactly as the common petioles of pinnate leaves; whilst those which do not flower, lengthen, remain upon the tree, and form true permanent branches.

These details tend to prove that the differences in the duration of plants only result very indirectly from their anatomical structure, and serve to explain how, in the

same natural families, we so frequently find plants of various durations.

The individual plants proceeding from fecundated germs (seeds), or unfecundated ones (bulbs, tubercules, or young shoots), are some of them endowed with the faculty of drawing up the sap by their own roots, and others are devoid of this faculty, but are capable of receiving the sap drawn up by the others; thus, the individuals proceeding from seeds are almost always provided with roots to nourish them. The Misseltoe is an example of a plant, which, although proceeding from a seed, has no true root; and its neck, implanted upon another plant, is nourished at its expense, exactly as a bud inserted by grafting. The individuals proceeding from bulbs or tubercules are similar to those from seeds, as regards the existence of roots.

Individuals produced in the manner of buds are constantly devoid of roots, and are nourished by the sap which is transmitted to them through the woody body of the plant upon which they grow; but if by any cause the development of adventitious roots from the lenticils be favoured there, then these individuals can live when separated from the one which gave birth to them. The processes by which we obtain new individuals are known by the names of making Cuttings or Layers; the graft is nothing but the transplanting of a young shoot. The laws relating to the duration of plants, or, rather, the manners of expressing these laws, are subordinate to the ideas adopted with regard to vegetable individuality; but as this subject is entirely physiological, I shall here confine myself to stating, from the preceding considerations, that, with a small number of exceptions perhaps even doubtful, plants are aggregations of as many individuals as there have been seeds or buds developed to concur in their formation; and that the plant is conse-

quently a compound, being analogous to the Polypes or Botryllæ in the animal kingdom.

This formation of new individuals, naturally grafted upon that which gives birth to them, is not limited; and in this sense it is true to say, that if a tree be considered as a single individual, its duration is infinite, and that it only dies by accident. This proposition, which might appear strange without reflection, is not in reality more singular than if it were said that an aggregation of animals which multiply without cessation, could not last for an infinite period.

CHAPTER II.

OF VEGETABLE SYMMETRY.

When the kingdom of inanimate nature began to be studied, there were only seen, as it were, irregularities, intermixed, however, here and there with more or less evident symptoms of a regular order. How was it with regard to astronomy? The indications of a regular order were evident; but anomalies apparently inexplicable, such, for example, as the retrogradations of stars, made persons believe that the laws would never be discovered. These laws have been discovered, and the apparent irregularities have become the most beautiful confirmations.

How was it with respect to mineralogy? The irregularities were so numerous, and the cases of regular

forms so rare, that it seemed almost impossible to discover any general law; by degrees it was perceived that almost all, and probably all amorphous bodies might be reduced to the form of crystals, and, consequently, that regularity existed in their nature. Among crystals themselves, it was perceived that a number of very different forms were simple modifications of a few primitive ones; these primitive forms have not only been reduced to a very small number, but the principal circumstances which determine the secondary forms have been arranged; and here, as in a great number of dynamic phenomena, it has been seen that the irregularities result from the simultaneous action of several regular causes which are increased and complicated in the results.

If we examine more closely the progress of Crystallography, we shall see that Romé-de-l'Isle, considering crystals as single bodies, explained their anomalies by truncations, whilst Haüy, going back in theory to the primitive molecules, although they do not come under our observation, was enabled to explain, in the most happy manner, the most complicated forms, by referring them to the different modes in which the molecules are united together. The first reasoned as those botanists do, who consider a leaf or corolla as a single whole, notched upon its margins from some unknown cause; the second has served me as a guide, when I attempted to show that the different indentations, or divisions of the organs of plants, were essentially connected with the various modes and different degrees of their aggregation.

There has been, then, a similarity in the progress of these two sciences; let us now see if there be any in their nature.

Does this regularity exist in organized bodies, and can the anomalies, so frequent in them, be owing, as in

minerals, to complications of causes, each of which, considered individually, would produce a regular effect?

Those who believe most in the normal regularity of organized bodies have perceived that it cannot be submitted to the same laws as that of minerals, &c.; that in particular no truly geometrical regularity is met with in them; but, although it is, perhaps, impossible to find a flower with all its petals geometrically equal, or a leaf with its two sides mathematically alike, it cannot be denied that, even upon the most superficial examination, we are not struck with the kind of regularity of these organs. The name of SYMMETRY has been given to this ungeometrical regularity of organized bodies. That these, particularly vegetables, present a multitude of examples of exact symmetry, is what no one can deny; and to these the name of regular bodies has been given, to point out the fact, without pretending to compare this regular symmetry or this regularity with the geometrical order of crystals. But it cannot be denied that in certain rather numerous cases the symmetry appears deranged; does this symmetry any longer exist in the cases of irregularity? or can this apparent derangement of it be produced by regular causes?

Even to the present day, the first of these opinions has been held; all the irregularities of plants and animals have been described, without its being thought that they conceal an order submitted to general laws. Each unusual form of an organ received a new name, and it became impossible to recognize their analogy with one another. Each unusual form of a body was considered either as a monstrosity if it were rare, (and the old botanists were contented with this unmeaning word to dispense with the study of it,) or as a distinct species, if the phenomenon were frequent, and thus all correct means of distinguishing organs were lost. They could not even

be classed with any method, for the least anomaly observed between any two individuals or groups would prevent all their other analogies from being recognised.

But the more the number of known beings increased, and the more carefully they were studied, the more were naturalists convinced of the principle which I have been the first, or one of the first, to declare in general terms, viz., that it is almost certain that organized beings are symmetrical or regular when considered in their type, and that the apparent irregularities of plants are connected with phenomena constant within certain limits, and capable of existing either separately or collectively, such as the abortion or degeneration of certain organs, their union with one another, or with others, and their multiplication after regular laws.

I shall here confine myself to giving a few considerations upon the importance and utility of this method in studying plants, both as regards their organization and classification.

The number of truly distinct organs is found to be prodigiously reduced when we analyze their nature; we see that several to which an important character has been attributed are only simple modifications of others; and we can recognise the same organ under different appearances, and consequently follow a true comparative Organography.

All the numerous class of facts, known under the name of monstrosities, which it was impossible to understand by the old system, and were therefore left unstudied—all this class, I say, has been elucidated, and taken a new interest, since they have been examined in their true point of view,—as indications for recognising the normal symmetry of beings. Monstrosities are, as it were, experiments which nature makes for the profit of the observer: here we see what are the organs, when

they are not united together, and we perceive what they really are when an accidental cause has not prevented them from enlarging. Proceeding thus from the opinion that the primitive nature is symmetrical, that irregularity is produced by different causes which alter this symmetry, we understand that monstrosities are owing to certain variations of these causes, and that, consequently, they may sometimes enable us to know the causes of derangement when their action has been increased or freed from all complication; at other times they may show us the symmetrical state when the causes which change it have been weakened or destroyed.

The whole theory of natural classification evidently rests upon the intimate knowledge of the organs and their modifications. The arrangement of plants in natural orders supposes, in my opinion, that we may one day be able to establish the characters of these orders upon what forms the base of their symmetry, and to refer the various forms of the species or genera to the action of causes which tend to alter the primitive symmetry. Thus, each leaf, like each class of crystals, may be represented by a regular state, sometimes visible, sometimes imaginary; this is called its TYPE: unions, abortions, degenerations, or multiplications, separate or combined, modify this primitive type so as to produce the constant characters of the beings they compose. These modifications are constant within certain limits, like the secondary forms of crystals. But each genus, each species, is more or less submitted to the causes which determine them, for plants which have the same type are not more identical than the crystals which have similar primitive molecules. If botany is much behind mineralogy in this respect, it results, on the one hand, from the much greater multiplicity of forms and causes of action; and, on the other, from all these facts being

submitted to a peculiar force (the vital force), the laws of which are much more obscure and difficult to study than those of affinity and attraction.

The simple description of vegetable facts and forms has been singularly improved since the knowledge of some general laws has caused describers to reflect upon what they see. Those who refuse to believe these laws, may, without doubt, describe the aberrations as the natural state, because nothing causes them to doubt that what they see is contrary to order; they may easily neglect minute organs, because nothing indicates their existence, and they may take much trouble in describing in detail certain peculiarities, which a few words, founded upon analogy, would have expressed with more clearness. Lastly, when two persons have described the same object in a contradictory manner, which unfortunately is not seldom the case, we have evidently no other means of discerning the truth than by the greater or less analogy of the descriptions with the laws of symmetry. For, in order to place plants in a rational order, we most constantly decide it upon more or less incorrect descriptions, for the period no longer exists when one man can see for himself all known plants.

Thus, in proportion as science makes new progress, we more and more perceive the necessity of knowing the general laws of organic symmetry. This necessity, perceived by all those who love general truths, has caused two divisions or schools to arise.

Some have endeavoured to establish laws upon the structure of beings from general considerations, and, as it is usually said, *à priori*. Others have attentively observed the facts which would seem to remove laws from regularity; they have seen that by separating almost all after uniform principles, and thus grouping the apparent irregularities, they referred them again to

regular laws, and ascending from partial to general facts, they were enabled to recognise the laws of symmetry *à posteriori.*

Those who are attached to the second of these two methods perform two parts in the general economy of the science: on the one hand, they collect with care all the facts in detail in order to derive general laws which, gradually compared together, may lead to other laws a little more general; on the other hand, they examine as simple hypotheses, to be verified or rejected, opinions conceived *à priori,* and try to perceive in what points the partial laws which they have recognised approach, or from what they depart. This course appears to me the same as that which is followed in all the physical sciences, the only one which can lead to general truths. If there still exist botanists who can believe, either that there are no general laws in the structure of organized beings, or that it is not worth while to search them out, I am persuaded that it can only result either from their being frightened by the multitude of facts in detail, or from their having studied only a small number of objects selected without method from those found within their reach.

I shall now proceed to give a summary of this work under an aphoristical form, which may be able to give some idea of these principles of symmetry; this will be the object of the following chapter.

CHAPTER III.

GENERAL SUMMARY OF THE STRUCTURE OF PLANTS.

1st. A plant is an organized and living being, devoid of voluntary motion, having neither nerves, muscles, nor a central cavity resembling a stomach, and always, or nearly always, attached to the soil from which it draws its nourishment.

2d. Plants are either wholly, or in a great measure, composed of membranous CELLULES, closed on all sides, more or less united together, and enclosed, at least in their young state, in a membranous cuticle. Those which are entirely thus formed bear the name of CELLULAR PLANTS (Book i. Ch. 2 and 16).

3d. Those which are thus formed in part, and which are called VASCULAR PLANTS, present, besides the cellules, cylindrical tubes which are called VESSELS; these are never naked, but always surrounded by cellules (Book i. Ch. 3 and 16).

4th. In vascular plants we observe moreover:—1st, that the cellules and vessels are united in very different degrees, so as frequently to leave between them empty spaces, called INTERCELLULAR PASSAGES; 2d, that besides the purely membranous vessels, there are bodies rolled spirally, and endowed with great elasticity, which are called TRACHEÆ; 3d, that their cuticle is pierced (at least, in almost every part exposed to the air) with

pores or STOMATA, which appear to be evaporating organs (Book i. Ch. 2, 3, 5, 6).

5th. The cellules are endowed with the faculty of uniting together, of absorbing the moisture around them, and probably of contracting and dilating. They are round, or more or less elongated; the former inclose the feculent, mucilaginous, or resinous matters which they have elaborated, of which the latter contain little or none. The round ones form the parenchyma; the long ones (by themselves in cellular plants, united with the vessels in vascular ones) compose the fibres or nerves (Book i. Ch. 2, 4).

6th. The passages between the elongated cellules, or the vessels, appear eminently to serve for carrying the lymph, *i. e.* the as yet unelaborated watery juices. Those which are formed among the round cellules contain the more stagnant juices (Book i. Ch. 2).

7th. The vessels, whatever their form, seem eminently intended to contain air or gas, and are true aerial canals, at least in the ordinary course of vegetation (Book i. Ch. 3).

8th. Certain particular points of the surface of plants, and especially of vascular ones, are more eminently endowed with the faculty of absorbing water. They are called SPONGIOLES, and are situated at the extremity of roots, at the top of the style, and on the surface of seeds (Book i. Ch. 7).

9th. Dilatations of the intercellular passages, or, in certain cases, ruptures of the cellules, cause irregular cavities in the interior of the tissue. These receive the name of AIR-CAVITIES when filled with air, or of RECEPTACLES OF PROPER JUICE when they contain an elaborated juice (Book i. Ch. 11, 12).

10th. GLANDS or glandular surfaces are some of them composed only of cellular tissue, others of cellular tissue

and vessels; both secrete special juices, but the first appear (at least in certain floral organs) to be excrementitial, and the second recrementitial (Book i. Ch. 9).

11th. The surface of plants exposed to the air is often invested with HAIRS, which are prolongations formed of projecting cellules. Some of these hairs are protecting organs for the surfaces; the others the supports or canals of excrementitial glands. They are always situated upon the nerves, whilst the stomata are always upon the parenchyma (Book i. Ch. 6 and 10).

12th. A vascular plant, considered lengthways, is composed of two bodies opposed by their bases (stem and root), and which grow in a contrary direction to one another. Their point of junction is called the NECK (Book ii. Ch. 1, 2).

13th. The body which descends, or the ROOT, elongates indefinitely by its extremity alone; does not become green by the action of the sun, except at its extremity; bears neither leaves nor flowers, and serves to fix the plant in the ground and to draw up its nourishment (Book ii. Ch. 2).

14th. The body which rises upwards, or the STEM, elongates throughout its whole length till the period when it ceases to grow, unless by the development of a body resembling itself (branch) and which is grafted upon it. It becomes green on exposure to the light throughout its whole length, at least in its young state, bears leaves and flowers, and transmits to them the nutriment absorbed by the roots (Book ii. Ch. 1).

15th. The stem of vascular plants is sometimes cylindrical, composed of a single system (the WOODY BODY), which increases by the development of new fibres internally; sometimes conical and composed of two systems (the WOODY BODY and BARK), which increase in diameter by means of layers which are

developed upon the surface of each of these systems which is in contact with the other system. To the first the name of ENDOGENS is given, to the latter that of EXOGENS. The structure of the root of each class is similar to that of the stem (Book ii. Ch. 1, 2).

16th. The stem of vascular plants is furnished laterally with appendicular organs, which seem formed by the expansion of one or more fibres (Book ii. Ch. 3).

17th. These appendicular organs, although very different from one another in their appearances and uses, seem however entirely identical in their original nature (Book iii. Ch. 2, sec. 18).

Those which are already formed in the embryo, bear the name of COTYLEDONS, or SEED-LEAVES; those which are produced immediately afterwards, PRIMORDIAL LEAVES. The following bear simply the name of LEAVES. Those which immediately surround the flower receive the name of BRACTS, and the flower itself is composed of several verticils of appendicular organs, much modified (Book ii. Ch. 3; Book iii. Ch. 1, 2).

18th. The appendicular organs perform, according to their position and mode of development, several different functions, of which the principal are :—

1st, That of nourishing organs, as the cotyledons and leaves;

2d, That of protecting organs, as the scales of buds, bracts, sepals, petals, carpels in their last stage;

3d, That of fructifying organs, as the stamens, and the carpels during the first stage of their existence. Several partake of both of these functions (Book ii. Ch. 3; Book iii. Ch. 1, 2, 3).

19th. The nourishing appendicular organs are, at their origin, alternate in endogenous plants, called also for this reason MONOCOTYLEDONS; opposite or verticillate in Exogens, called also DICOTYLEDONS. In the

course of their development, those of Endogens always remain alternate or spiral, those of Exogens may either remain in their primitive state or take a spiral disposition (Book ii. Ch. 3).

20th. The appendicular organs which compose the flowers are, in both classes, disposed in concentric verticils; the innermost are sometimes spiral (Book iii. Ch. 2).

21st. The protecting appendicular organs hold a middle station, in form, size, colour, and often also in position, between the two other classes; and we frequently see them metamorphosed, either into organs decidedly nourishing, or more rarely into fructifying ones (Book iii. Ch. 1).

22d. The appendicular organs are generally composed of a petiole and limb, but one of them may be wanting. The PETIOLE, which is the bundle of fibres not as yet disunited, has its fibres longitudinal; the LIMB, which is the part formed by the expansion of the fibres, has them more or less diverging. These fibres of the limb, or NERVES of leaves, are generally curved in Endogens, and separate at angles more or less acute in Exogens (Book ii. Ch. 3).

23d. The nerves of curvi-nerved leaves converge towards the apex, or diverge from a middle bundle. Those of anguli-nerved ones are pinnate, palmate, or pedate; but the portions of the limb of the three last classes are penni-nerved, so that this form seems essential to the leaves of Dicotyledons (Book ii. Ch. 3).

24th. The leaves of Dicotyledons are the only ones which have been seen, either composed of joints or leaflets, or furnished with lateral stipules.

25th. GERMS, or the undeveloped rudiments of new individuals, appear able to arise from all parts of the surface; but there are certain points where they are

developed in preference, such as the axils of the appendicular organs and the extremities of the fibres of their limbs (Book iii. Ch. 1, 5).

26th. The germs which are placed in the axils of the appendicular organs, along the stem or petiole, may be developed by the action of the nutritive forces alone. Those which are situated at the extremity of the lateral fibres of the limb almost always require (except in *Bryophyllum*), in order to be developed, a particular operation called FECUNDATION (Book iii. Ch. 5).

27th. The germs which are developed without fecundation most frequently arise united to the mother plant without having proper envelopes, and without shooting out roots: they then form branches. Some separate when they are furnished with a tubercule or store of nutriment: they then form separate individuals and produce roots (Book iii. Ch. 5).

28th. Every stem or branch can shoot out adventitious roots. In Dicotyledonous trees, these spring from the lenticels; every branch, furnished with them or capable of producing them, may easily be separated from the mother plant and form a distinct being (Book iii. Ch. 5).

29th. The germs which are developed by fecundation are always contained in a closed envelope, furnished with the rudiments of a root and appendicular organs. They receive the name of EMBRYOS (Book iii. Ch. 4).

30th. The unfecundated germs perpetuate the varieties of the mother plant; the embryos only retain the characters of races or species.

31st. The appendicular organs which immediately surround the flowers, or the bracts, hardly ever have leaf-buds developed in their axils; this is still more seldom the case in the appendicular organs which compose the flowers (Book iii. Ch. 1, 2).

32d. The buds, or germs, which are developed into

branches, are often protected in their young state by scales which are nothing but the outermost appendicular organs of the young branch, modified by their position (Book iv. Ch. 6).

33d. The flower, in which is the apparatus destined for the fecundation, is a kind of terminal bud formed of verticillate appendicular organs, the outermost of which act the part of protecting organs, the innermost of sexual ones; but they are capable of changing their office by being transformed either into leaves, or from one into another (Book iii. Ch. 2).

34th. In the modifications or transformations of the appendicular organs, each is only usually converted into the nature of the verticil which follows or precedes it in the order of development or position. The first phenomenon, which is the most frequent, has received the name of Ascending or Direct Metamorphosis, and the second that of Descending or Retrograde Metamorphosis (Book iii. Ch. 2).

35th. The flower being formed of verticillate organs is necessarily terminal with regard to the pedicel, at least when the pedicel is not prolonged beyond it, as happens accidentally in certain proliferous flowers (Book iii. Ch. 1).

36th. Pedicels near one another, and composing the same inflorescence, are disposed after three systems:—1st, the outer or lateral ones are developed first, and the flowering proceeds indefinitely in a centripetal order; 2d, the central one, which is necessarily terminal, flowers first, and the flowering proceeds in a centrifugal order; 3d, these two laws are combined, the one affecting the general axis, the other the lateral branches (Book iii. Ch. 1).

37th. The number of verticils in phanerogamous flowers, is usually four; but it may vary, being either

less when one is absent or united to the neighbouring one, or more when one is composed of several verticils or similar rows (Book iii. Ch. 2).

38th. The almost universal disposition of the pieces of each verticil or row, is that of being alternate with those of the preceding verticil or row (Book iii. Ch. 2).

39th. The number of pieces of each floral verticil is generally three in Monocotyledons, and five in Dicotyledons (Book iii. Ch. 2).

40th. All the caulinary, and especially the appendicular parts of plants, are capable of being united together, especially during their infancy; the union is a distinct phenomenon from the graft; it is the more easy in proportion as the nature of the organs is more analogous; it takes the name of COHESION when it comes between similar organs, and ADHESION when they are different. The different degrees of adhesion of similar organs, or of the parts of the same organ, determine either its integrity, or the divisions or indentations of most organs.

41st. All the caulinary or appendicular parts are capable, when they are filiform, of expanding into limbs; and when naturally in the form of a limb, of presenting a cylindrical appearance. They may also put on, within certain limits, forms, sizes, texture, colours, and even functions and positions, varying in different points of the same individual or analogous ones; this constitutes the DEGENERATIONS or metamorphoses of organs.

42d. All the appendicular organs, verticillate or spiral, are capable of presenting multiplications of number, both in the increase in the number of the verticils or spires, or in the increase in that number of the pieces in each of the systems.

43d. All the organs of plants are susceptible of being

abortive either wholly or in part, and, consequently, of presenting simple rudiments or leaving empty spaces.

44th. All the irregularities observed in the symmetry of verticillate organs, and especially in that of flowers and fruits, appear to result from one of the causes mentioned in the four preceding paragraphs, or from the combination of several of them.

45th. In particular, the unity or solitariness of the verticillate organs can only exist by the abortion of those which ought to complete the verticil or spire, or by the union of several.

46th. The fruit is formed by the CARPELS, which may be free, or cohere together, or adhere to neighbouring parts (Book iii. Ch. 4).

47th. As the two margins of each carpellary leaf can bear ovules, the solitariness of the seed in a carpel, free or united to others, can only result from an abortion (Book iii. Ch. 3).

48th. The embryo must be considered as the development, by fecundation, of a germ situated at the extremity of one of the lateral fibres of the carpellary leaf (Book iii. Ch. 4).

49th. Cryptogamous plants present, in their organization, only partial indications of symmetry, which, in the present state of the science, are not sufficient to enable us to recognise the laws. We cannot affirm particularly whether there is fecundation in all Cryptogamous plants, or whether several are not reproduced by unfecundated germs.

ERRATA.

Vol. I. p. 133, line 20, *for* "annular," *read* "annual."
144, line 7, *for* "Alburum," *read* "Alburnum."
267, line 5 from bottom, *for* "two pair," *read* "one pair."
278, the last line, *for* "Euphorbium," *read* "Euphorbia."
279, line 10, *for* "Chicorium," *read* "Cichorium."
309, line 14, *for* "Polytricha," *read* "Polytrichum."

Vol. II. p. 7, line 18 from bottom, *for* "Veronica hederacea," *read* "V. hederifolia."
59, the last line, *for* "Berberidæ," *read* "Berberideæ."
176, line 23, *for* "Æsculus," *read* "Castanea."
212, line 21, *for* "Mullow," *read* "Mallow."

ALPHABETICAL TABLE

OF THE

GENERA AND FAMILIES MENTIONED AS EXAMPLES IN THE COURSE OF THIS WORK.

DESCRIPTION OF THE PLATES.

PLATE I.

Cellular Tissue.

Fig.
1. Round Cellular Tissue.
2. Hexahedral ditto ditto.
3 Ditto ditto ditto, showing the Intercellular Passages.
4. A Section of a portion highly magnified, from Kieser.
5, 6. Cellules separated from the others.
7. Elongated cellules of the wood and bark.
8. Elongated cellules which surround the vessels.
9, 10. Muriform cellular tissue from the Medullary Rays.

PLATE II.

The Vessels.

Fig.
1. A longitudinal section of a fibre of the leaf of *Tritoma Uvaria*, showing in *a.a.* the Tracheæ, and *b.b.* the striped vessels.
2. *a.a.* the striped, and *b.b.* the dotted, vessels, from the stem of *Lycopodium denticulatum.*
3. A Trachea of *Musa Paradisiaca*, showing the band to be composed of several spiral fibres.
4. A Trachea, from Dutrochet.
5. *a.a.* striped, and *b.b.* dotted, vessels, from the stem of *Smilax aspera.*
6. A strangulated vessel.
7. *a.* a reticulated ditto; *b.* an example, from Mirbel, showing a trachea changing into a striped or annular vessel.

PLATE III.

Cuticle and Stomata.

Fig.
1. Cuticle and Stomata of *Pæonia.*
2. Ditto ditto of *Iris Germanica.*
3. Ditto ditto from the lower surface of the leaf of *Lycopodium denticulatum.*
4. Portion of a longitudinal and vertical section of a leaf of *Tritoma Uvaria*, showing the cellules of the cuticle and those of the parenchyma.
5. A longitudinal section of the same leaf, made parallel to the surfaces, showing the longitudinal fibres of the nerves, the parenchyma, and bundles of Raphides.
6. The Raphides more highly magnified.
7. Portion of a transverse section of a leaf of *Yucca aloifolia*, showing the difference between the compact cellules of the cuticle and those of the parenchyma.
8. A vertical section of Fig. 2.

Hairs.

A. A cupulate hair.
B. A capitate ditto from *Petunia.*
C. An awl-shaped ditto, or sting from the Nettle.
D. A hair of *Malpighia.*
E. A simple hair.
F. Divided ditto.
G. Moniliform ditto.
H. A hair from *Malva.*
I. A shield-shaped ditto from the leaf of *Elæagnus.*

PLATE IV.

Stems.

Fig.
1. A fasciculated branch of *Spartium junceum.*
2. A transverse section of the stem of a Juniper, half the natural size, showing a *gelivure*, or frozen layer. (*See* vol. i. p. 163).
3. Section of the annual stem of *Ferula communis.*

PLATE V.

Stems.

Fig.
1. Bifurcation of a branch of the Horse-chestnut.
2. A transverse section of a branch of the Ebony-tree (*Diospyros Ebenum*), showing the sudden difference of colour between the Duramen and Alburnum.
3. Transverse section of *Quercus Tanza*, showing the large medullary rays, and the very thick cellular layer of the bark.

PLATE VI.

Ficus Elastica.

Portion of a shoot of *Ficus elastica*, showing how the stipules inclose the young leaves at their infancy; also a fragment of the bark with lenticils, from one of which an adventitious root is seen proceeding.

PLATE VII.

Leaves.

Fig.
1. Pinnatifid leaf of *Comptonia asplenifolia.*
2. A leaf of *Acacia heterophylla*, with the common petiole very slightly dilated, and bearing two pair of partial petioles furnished with leaflets.
3. Another leaf of the same plant, with the common petiole more dilated, but still bearing several pairs of partial ones.
4. Another leaf, with the petiole still more dilated, and bearing very few partial ones.
5. Example of the same plant, with the petiole entirely dilated into a phyllodium and no longer bearing leaflets. The flowers in compact heads, pedicellate and axillary.

PLATE VIII.

Root.

Extremity of one of the branches of the root of *Pandanus odoratissimus*, of the natural size, showing the large scaly spongioles which terminate the principal branches.

PLATE IX.

Leaves.

Fig.

1. Leaf or portion of the stem of an Indian Arum, showing the sheathing petiole and pedalinerved limb.
2. Leaf of *Liquidambar Styraciflua;* an example of a palmatifid, palminerved limb, with serrated lobes.

PLATE X.

Leaves.

Fig.

1. Leaf of *Ocotia Guianensis*, showing the false nerves or marks caused by the pressure of neighbouring nerves during its infancy; an example of an oblong leaf, pointed at both ends, slightly penninerved, with reticulated lateral nerves, and entire margins.
2. Leaf of *Begonia Articulata*, the joints being formed by the dilation of the winged petioles, the leaflets which ought to spring from the contractions being entirely wanting.
3. Leaf of *Desmodium triquetrum*, with two stipules and a winged petiole, terminated by a single leaflet.
4. Leaf of *Sarcophyllum carnosum*, composed of a petiole and terminal leaflet.
5. Different states of the leaves of *Lebeckia nuda*, showing the petiole furnished with rudiments of leaflets.

PLATE XI.

Leaves.

Fig.

1. Leaf of *Bauhinia purpurea*, probably formed by the constant union of two leaflets.
2. Leaf of *Passiflora perfoliata*, emarginated at the base.
3. Leaf and stipules of *Lardizabala triternata*, which had better be called *biternata*. An example of foliaceous, caulinary, caducous stipules.

PLATE XII.

Buds of the Horse-chestnut.

Fig.

1. A young branch with the buds as yet undeveloped, and with lenticils and cicatrices of the old leaves.

2, 3, 4 and 5. The buds more developed, showing the progression from the scales to the leaves, proving the scales to be petiolaceous.

PLATE XIII.

Leaves.

Fig.

1. Leaf of *Desmodium gyrans*, showing the three leaflets and the stipels.

2 and 2*. Leaves of *Mimosa sensitiva*.

3. Leaf of *Melianthus cosmous*, showing the stipules.
4. Leaf of *Melianthus major*, showing the great interpetiolary stipules, with a longitudinal line through their centre, proving that they are formed by the union of two.

PLATE XIV.

Union of Leaves.

Fig.

1. Two leaves of *Laurus nobilis* united together.
2. A similar example from *Justicia oxyphylla.*

PLATE XV.

Buds.

Fig.

1, 2, and 3. Radical buds of *Pæonia officinalis*, in different states of development.

4, 5, and 6. Buds of *Amelanchier* in different degrees of development. We see the stipules and bracteoles resembling each other.

7 and 8. Buds of *Pyrus hybrida* at different ages.

9. Progress of the scale into leaves, showing that these buds are of a fulcraceous nature.

PLATE XVI.

Varieties.

Fig.

1. Top of the winged branch of *Xylophylla*, enlarged; showing the origin of the flowers from each little notch.
2. Portion of a branch of *Capparis quadriflora*, with spiny stipules on each side of the leaf, and the pedicellate flowers springing in a vertical series above the axil.
3. *Ruscus aculeatus.* The alternate sheaths may either be considered as true cotyledons, or as primordial leaves if the cotyledons be concealed in the seed. The leaves resemble scales at the bases of the leaf, like compressed branches.
4. The axis of the cone of *Larix Europæa* prolonged into a branch.

PLATE XVII.

Proliferous Rose.

Fig.

1. A rose with a flower bud in nearly the ordinary state, and with a proliferous flower; in which the calyx is changed into leaves, and does not adhere to the ovary; the petals and stamens are nearly in the state of a semi-double rose; the axis is prolonged in the centre of the flower bearing a second.
2. The above flower seen from below.
3. The same, cut through the centre, the sepals and petals being removed.
4. An ordinary petal.
5. An ordinary stamen.

6 and 7. Stamens changing into petals.

8. A petal of the supernumerary flower.
9. A stamen of ditto ditto.
10. A carpel of ditto ditto.

PLATE XVIII.

Varieties.

Fig.

1 and 2. Two flowers of *Podospermum laciniatum;* one in the ordinary state with the limb changed into the pappus; and the other with a five-lobed calyx.

3 and 4. Two flowers of *Capsella Bursa-pastoris* with ten stamens: the four petals being changed into stamens in addition to the six ordinary ones.

Fig.
5. A flower of *Datura fastuosa*, showing a triple corolla.
6 and 7. A monstrosity of *Gentiana purpurea*, in which the ovarium is formed of two rows of carpels, all bearing ovules; the outer row has four, the inner two carpels.
8, 9, 10, and 11. Different states of the flowers of *Phlox amœna* from the same plant, showing the different combinations of the petals, from their being nearly perfectly free, to their usual gamopetalous state.

PLATE XIX.

Æstivations.

In these figures, *s* designates the sepals, *p* the petals, *t* the tepals, and *b* the bracts.

Fig.
1. *Papaver Rhœas*; petals rumpled, sepals imbricate.
2. *Mahernia pinnata*; petals contorted, sepals valvate.
3. *Tradescantia Virginica*; petals imbricate, sepals valvate.
4. *Philadelphus coronarius*; petals contorted, sepals valvate.
5. *Cistus albidus*; petals contorted, sepals quincunxially imbricate.
6. *Clematis florida*; sepals induplicate; *s.* one seen from the inner side.
7. *Sparmannia Africana*; petals half induplicate, half imbricate, sepals valvate.
8. *Spartium junceum*; petals in vexillary æstivation; *v.* (vexilla), the standard; *a. a.* (alæ), the wings; *c.* (carina), the keel.
9. *Daphne alpina*; perigone imbricate.
10. *Metrosideros lanceolata*; sepals and petals quincunxially imbricate.
11. *Plantago media*; tepals imbricate.
12. *Viola arvensis*; sepals and petals quincunxially imbricate.
13. *Poterium Sanguisorba*; sepals in regular æstivation.
14. *Pancratium maritimum*: the outer row of the perigone formed of curved pieces, the inner, of flat and valvate ones.
15. *Hoya carnosa*; petals valvate.

PLATE XX.

Structure of Ovaries with a central placenta.

Fig.
1. *Stellaria graminea.*
2. *Cerastium arvense.*
3. *Arenaria tenuifolia.*
4. *Arenaria marina.*
5. *Silene*, (a species very near *S. conica.*)
6. *Silene nutans.*
7. *Claytonia perfoliata.*
8. *Telephium Imperati.*

PLATE XXI.

Monstrosities.

Monstrosity of an apple, produced by two flowers united by their peduncles. *Centaurea* with the peduncles united.

PLATE XXII.

Germinations.

Fig.
1. *Euphorbia Helioscopia*; a monstrosity with four cotyledons, formed by the union of two embryos.

Fig.

2. *Cobæa scandens*, with its stem, cotyledons, and primordial leaves.

3, 3*, and 3**. *Tropæolum peregrinum*, with its radicle; 3. the seed containing the cotyledons; 3**. the seed beginning to open at the base; 3* the cotyledons are seen, their covering being removed.

PLATE XXIII.

Germinations.

Fig.

1. A species of *Bombax*.
2. *Quercus Suber*.
3. *Cactus Melocactus*.

THE END.

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Fig. 2.

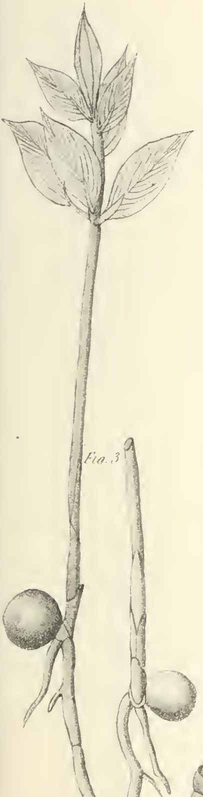

Fig. 3

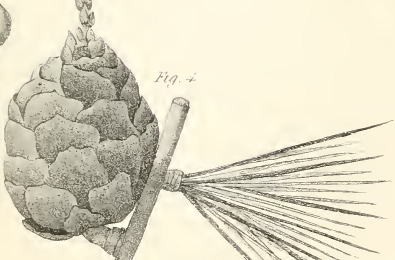

Fig. 4

Hadeley lith 3 Wellington St Strand


Fig. 4
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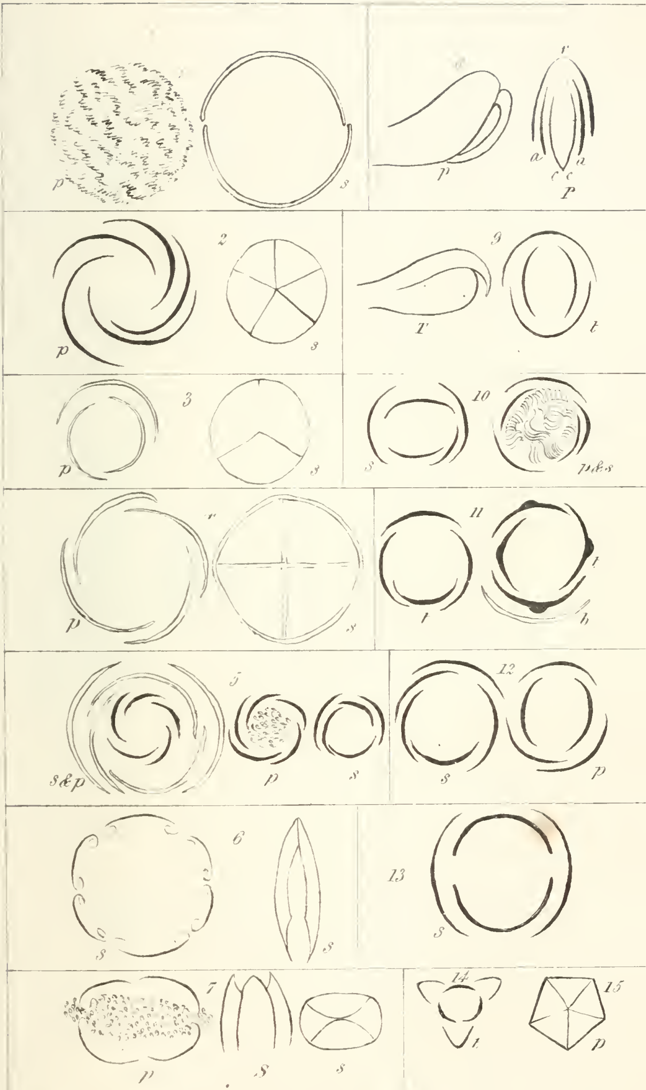

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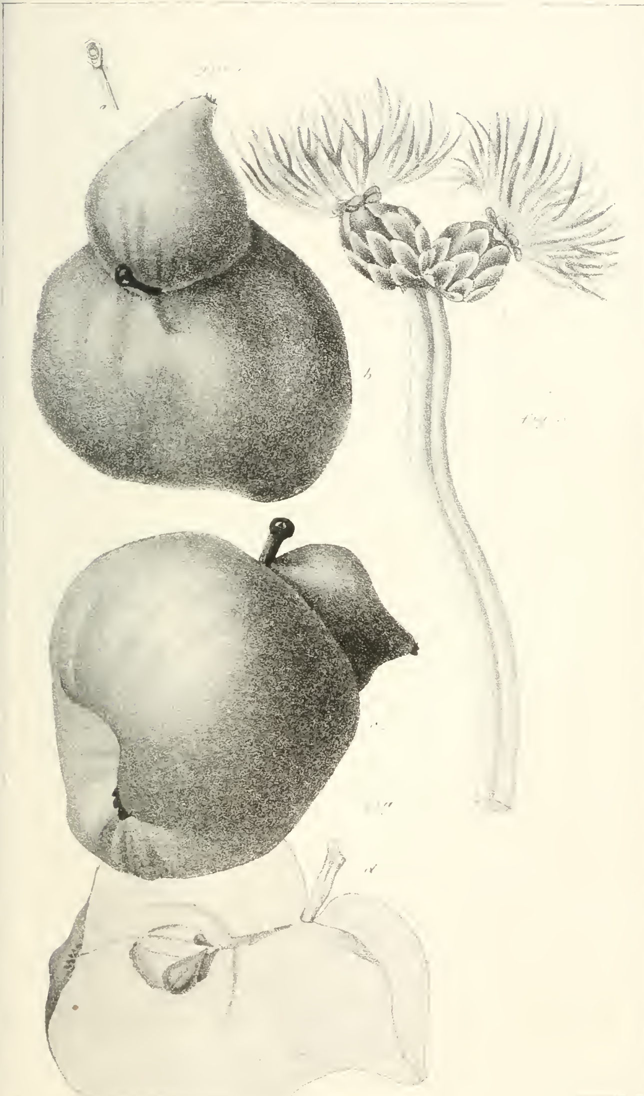
14
t
15
p


1
a
b
c
2.
b
3.
a
b
c
b
5
a
c
6.
b
c
7
b
8.
a
b
c



Maddey litho Wellington St Strand

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